TRANSACTIONS

OF THE

AMERICAN FISHERIES SOCIETY

1922

FIFTY-SECOND ANNUAL MEETING

MADISON, WISCONSIN

SEPTEMBER 6, 7, 8, 1922

TRANSACTIONS

of the

American Fisheries Society

"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

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September 6, 7, 8, 1922

Volume LII

1922-1923

Edited by Ward T. Bower

Published Annually by the Society

WASHINGTON, D. C.

The American Fisheries Society

ORGANIZED 1870 INCORPORATED 1910

Officers for 1922-1923

President..................GLEN C. LEACH, Washington, D. C.
Vice-President................GEORGE C. EMBODY, Ithaca, N. Y.
Executive Secretary.........WARD T. BOWER, Washington, D. C.
Recording Secretary.......THOMAS E. B. POPE, Milwaukee, Wis.
Treasurer..................ARTHUR L. MILLETT, Boston, Mass.

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Fish Culture..........CHARLES O. HAYFORD, Hackettstown, N. J.
Aquatic Biology and Physics.........E. A. BIRGE, Madison, Wis.
Commercial Fishing..............GARDNER POOLE, Boston, Mass.
Angling........................JOHN P. WOODS, St. Louis, Mo.
Protection and Legislation..HARRISON W. VICKERS, Baltimore, Md.

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JOHN N. COBB..............................Seattle, Wash.

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FREDERIC C. WOLCOTT, *Chairman*...............Norfolk, Conn.
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WILLIAM C. ADAMS..........................Boston, Mass.
R. E. FOLLETT.............................Detroit, Mich.

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W. L. FINLEY.........................Jennings Lodge, Ore.
E. T. D. CHAMBERS..........................Quebec, Canada
ARTHUR L. MILLETT...........................Boston, Mass.
MAX D. HART...............................Richmond, Va.

Presidents, Terms of Service and Places of Meeting.

The first meeting of the Society occurred December 20, 1870. The organization then effected continued until February, 1872, when the second meeting was held. Since that time there has been a meeting each year, as shown below. The respective presidents were elected at the meeting, at the place, and for a period shown opposite their names, but they presided at the subsequent meeting.

1.	William Clift	1870-1872	New York, N. Y.
2.	William Clift	1872-1873	Albany, N. Y.
3.	William Clift	1873-1874	New York, N. Y.
4.	Robert B. Roosevelt	1874-1875	New York, N. Y.
5.	Robert B. Roosevelt	1875-1876	New York, N. Y.
6.	Robert B. Roosevelt	1876-1877*	New York, N. Y.
7.	Robert B. Roosevelt	1877-1878	New York, N. Y.
8.	Robert B. Roosevelt	1878-1879	New York, N. Y.
9.	Robert B. Roosevelt	1879-1880	New York, N. Y.
10.	Robert B. Roosevelt	1880-1881	New York, N. Y.
11.	Robert B. Roosevelt	1881-1882	New York, N. Y.
12.	George Shepard Page	1882-1883	New York, N. Y.
13.	James Benkard	1883-1884	New York, N. Y.
14.	Theodore Lyman	1884-1885	Washington, D. C.
15.	Marshall McDonald	1885-1886	Washington, D. C.
16.	W. M. Hudson	1886-1887	Chicago, Ill.
17.	William L. May	1887-1888	Washington, D. C.
18.	John H. Bissell	1888-1889	Detroit, Mich.
19.	Eugene G. Blackford	1889-1890	Philadelphia, Pa.
20.	Eugene G. Blackford	1890-1891	Put-in Bay, Ohio.
21.	James A. Henshall	1891-1892	Washington, D. C.
22.	Herschel Whitaker	1892-1893	New York, N. Y.
23.	Henry C. Ford	1893-1894	Chicago, Ill.
24.	William L. May	1894-1895	Philadelphia, Pa.
25.	L. D. Huntington	1895-1896	New York, N. Y.
26.	Herschel Whitaker	1896-1897	New York, N. Y.
27.	William L. May	1897-1898	Detroit, Mich.
28.	George F. Peabody	1898-1899	Omaha, Neb.
29.	John W. Titcomb	1899-1900	Niagara Falls, N. Y.
30.	F. B. Dickerson	1900-1901	Woods Hole, Mass.
31.	E. E. Bryant	1901-1902	Milwaukee, Wis.
32.	George M. Bowers	1902-1903	Put-in Bay, Ohio.
33.	Frank N. Clark	1903-1904	Woods Hole, Mass.
34.	Henry T. Root	1904-1905	Atlantic City, N. J.
35.	C. D. Joslyn	1905-1906	White Sulphur Spgs, W.Va.
36.	E. A. Birge	1906-1907	Grand Rapids, Mich.
37.	Hugh M. Smith	1907-1908	Erie, Pa.
38.	Tarleton H. Bean	1908-1909	Washington, D. C.
39.	Seymour Bower	1909-1910	Toledo, Ohio.
40.	William E. Meehan	1910-1911	New York, N. Y.
41.	S. F. Fullerton	1911-1912	St. Louis, Mo.
42.	Charles H. Townsend	1912-1913	Denver, Colo.
43.	Henry B. Ward	1913-1914	Boston, Mass.
44.	Daniel B. Fearing	1914-1915	Washington, D. C.
45.	Jacob Reighard	1915-1916	San Francisco, Calif.
46.	George W. Field	1916-1917	New Orleans, La.
47.	Henry O'Malley	1917-1918	St. Paul, Minn.
48.	M. L. Alexander	1918-1919	New York, N. Y.
49.	Carlos Avery	1919-1920	Louisville, Ky.
50.	Nathan R. Buller	1920-1921	Ottawa, Canada.
51.	William E. Barber	1921-1922	Allentown, Pa.
52.	Glen C. Leach	1922-1923	Madison, Wis.

* A special meeting was held at the Centennial Grounds, Philadelphia, Pa., October 6 and 7, 1876.

American Fisheries Society

ORGANIZED 1870

CERTIFICATE OF INCORPORATION.

We, the undersigned, persons of full age and citizenship of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 599 to 603, inclusive, of the Code of Law for the District of Columbia, enacted March 3, 1901, as amended by the Acts approved January 31 and June 30, 1902, hereby associate ourselves together as a society or body corporate and certify in writing:

1. That the name of the Society is the AMERICAN FISHERIES SOCIETY.
2. That the term for which it is organized is nine hundred and ninety-nine years.
3. That its particular business and objects are to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish; with power:

(*a*) To acquire, hold and convey real estate and other property, and to establish general and special funds.

(*b*) To hold meetings.

(*c*) To publish and distribute documents.

(*d*) To conduct lectures.

(*e*) To conduct, endow, or assist investigation in any department of fishery and fish-culture science.

(*f*) To acquire and maintain a library.

(*g*) And, in general, to transact any business pertinent to a learned society.

4. That the affairs, funds and property of the corporation shall be in general charge of a council, consisting of the officers and the executive committee, the number of whose members for the first year shall be seventeen, all of whom shall be chosen from among the members of the Society.

Witness our hands and seals this 16th day of December, 1910.

SEYMOUR BOWER	(Seal)
THEODORE GILL	(Seal)
WILLIAM E. MEEHAN	(Seal)
THEODORE S. PALMER	(Seal)
BERTRAND H. ROBERTS	(Seal)
HUGH M. SMITH	(Seal)
RICHARD SYLVESTER	(Seal)

Recorded April 16, 1911.

PART 1
BUSINESS SESSIONS

PROCEEDINGS
of the
American Fisheries Society
FIFTY-SECOND ANNUAL MEETING AT MADISON, WISCONSIN

September 6, 7, 8, 1922

The Fifty-second Annual Meeting of the American Fisheries Society convened in the State Capitol Building, Madison, Wisconsin, on Wednesday, September 6, 1922, at 10 o'clock a. m., President William E. Barber, of Madison, in the Chair.

First Session, Wednesday Morning, September 6, 1922

President Barber introduced Mr. Frank W. Kuehl, Executive Assistant to Governor Blaine of Wisconsin, who delivered an address of welcome.

The President called upon Mr. M. L. Alexander, of New Orleans, who made an eloquent respone.

REGISTERED ATTENDANCE

The registered attendance was 49, as follows:

ADAMS, WILLIAM C., Boston Mass.
ALBERT, W. E., Des Moines, Iowa.
ALEXANDER, M. L., New Orleans, La.
AVERY, CARLOS, St. Paul, Minn.
BALCH, HOWARD K., Chicago, Ill.
BARBER, W. E., Madison, Wis.
BIRGE, DR. E. A., Madison, Wis.
BROWN, ERNEST CLIVE, New York, N. Y.
BURKHART, J., Star Prairie, Wis.
CANFIELD, H. L., Homer, Minn.
COBB, EBEN W., St. Paul, Minn.
COBB, JOHN N., Seattle, Wash.
CRARY, F. O., Hudson, Wis.
CULLER, C. F., Homer, Minn.
DOWNING, S. W., Put-in Bay, Ohio.
FOSTER, FRED J., Neosho, Mo.
GANTENBEIN, D., Diamond Bluff, Wis.
GANTENBEIN, U. CARVER, New Albin, Iowa.
HANSEN, G., Osceola, Wis.
HARE, F. E., Manchester, Iowa.
HART, M. D., Richmond, Va.
HAYFORD, CHARLES O., Hackettstown, N. J.
HAYFORD, MRS. CHARLES O., Hackettstown, N. J.
HEUCHELE, G. L., Put-in Bay, Ohio.

HOLMES, WILLIAM W., New Orleans, La.
JENSEN, HAROLD, Spooner, Wis.
JUDD, E. T., Cando, N. D.
KULLE, KARL C., Suffield, Conn.
LEACH, G. C., Washington, D. C.
LIPINSKY, M. N., Winona, Minn.
LYDELL, DWIGHT, Comstock Park, Mich.
O'MALLEY, HENRY, Washington, D. C.
MERCIER, HONORE, Quebec, Canada.
MILES, LEE, Little Rock, Ark.
MILLETT, A. L., Boston, Mass.
MOLLAN, W. K., Bridgeport, Conn.
MOORE, DR. EMMELINE, Albany, N. Y.
PEARSE, A. S., Madison, Wis.
POPE, T. E. B., Milwaukee, Wis.
PRINCE, DR. E. E., Ottawa, Ont., Canada.
TAYLOR, H. F., Washington, D. C.
TERRELL, CLYDE B., Oshkosh, Wis.
TITCOMB, J. W., Hartford, Conn.
THAYER, W. W., Northville, Mich.
VICKERS, HARRISON W., Baltimore, Md.
WALCOTT, FREDERIC C., Norfolk, Conn.
WEBSTER, B. O., Madison, Wis.
WIRES, S. P., Duluth, Minn.
WOODS, JOHN P., St. Louis, Mo.

NEW MEMBERS

Since the last annual meeting the following 37 new active members have been elected:

ARNOLD, M. DEWEY, Bemus Point, N. Y.
BAYNE, BLISS, Chief Assistant Game and Fish Commissioner, Room 312, Capitol Bldg., Cheyenne, Wyo.
CANFIELD, H. L., Homer, Minn.

CLUBS:

CHERRY RIDGE FISHING CLUB, Honesdale, Pa.
FERNDALE ROD AND GUN CLUB, New Auburn, Wis.
GALESVILLE CONSERVATION CLUB, Galesville, Wis.
MASSACHUSETTS FISH AND GAME PROTECTIVE ASSOCIATION, Tremont Bldg., Boston, Mass.
MCKEESPORT BRANCH OF WILD LIFE LEAGUE OF PENNSYLVANIA, Theodore J. Herrmann, Sec., 218 Commercial Ave., McKeesport, Pa.
SWIFTWATER PRESERVE, Dr. Samuel S. Kneass, Treas., 1510 Walnut St., Philadelphia, Pa.

COMEAU, NAP. A., Godbout, Province of Quebec, Canada.
COOK, FRANK, Supt., Albany County Hatchery, Laramie, Wyo.
FRASER, DR. C. MCLEAN, Biological Station, Nanaimo, British Columbia.
GANTENBEIN, U. CARVER, New Albin, Iowa.
HART, M. D., Dept. of Game and Inland Fisheries, Library Bldg., Richmond, Va.
HOLMES, WILLIAM W., Dept. of Conservation, New Orleans, La.
JUDD, E. T., Game and Fish Commissioner, Cando, North Dakota.
KULLE, KARL C., Fish and Game Board, Suffield, Conn.
LAIRD, JAMES A., South Side Sportsmen's Club of Long Island, Oakdale, N. Y.
LAUERMAN, FRANK J., Marinette, Wis.

LIBRARIES:

BUREAU OF SCIENCE LIBRARY, Manila, P. I.
CALIFORNIA STATE FISHERIES LABORATORY LIBRARY, Terminal, Calif.
LIBRARY ASSOCIATION OF PORTLAND, 10th and Yamhill Sts., Portland, Oreg.
NEW YORK STATE COLLEGE OF AGRICULTURE LIBRARY, Ithaca, N. Y.
OHIO STATE UNIVERSITY LIBRARY, Columbus, Ohio.
UNIVERSITY OF ILLINOIS LIBRARY, Urbana, Ill.
PUBLIC MUSEUM OF MILWAUKEE, Milwaukee, Wis.

LOCKE, SAMUEL B., U. S. Forest Service, Ogden, Utah.
MARTIN, J. E., Kennedy Lake Hatchery, Tofino, British Columbia.
MARVIN, J. B., Jr., P. O. Box 544, Saranac Lake, N. Y.
NASON, R. B., 1410 South Grant Ave., Tacoma, Wash.
PUTMAN, BERT J., 462 Washington St., Buffalo, N. Y.
SIEMS, ALLEN G., Big Rock Trout Club Hatchery, St. Croix Falls, Wis.

STATES:

BOARD OF FISHERIES AND GAME, State Capitol, Hartford, Conn.
MARYLAND STATE CONSERVATION COMMISSION, Baltimore, Md.

TROUT BROOK CO., F. O. Crary, Pres., Hudson, Wis.
WALCOTT, FREDERIC C., Pres., Fish and Game Board, Norfolk, Conn.
WELLS, ARTHUR W., U. S. Bureau of Fisheries, Washington, D. C.

In addition the following have been added to the list of Corresponding Members:

DIRECTOR, ALL-RUSSIAN AGRICULTURAL MUSEUM, Fontanka 10, Petrograd, Russia.
DIRECTOR OF FISHERIES (BRITISH MALAYA), Singapore, Straits Settlements.
LIBRARY, NATIONAL MUSEUM OF NATURAL HISTORY, Paris, France.

A paper entitled "Oysters: The World's Most Valuable Seafood," was presented by Harrison W. Vickers. Discussion followed.

Mr. Vickers submitted the following telegram from Mr. W. McDonald Lee, dated Norfolk, Va., September 3, 1922:

Doctor Mott of New Jersey, Marshall of Connecticut and others urge me to go Madison advocate amalgamation Shell Fish Commissioners with American Fisheries Society or some form of affiliation. Wish you see any Shell Fish Commissioner and have proposition considered before convention. Think shell fish people ought to be taken in and given day or certain part on program every meeting American Fisheries Society.

Mr. Vickers said that at least he would like to see the organization invited to attend meetings of the American Fisheries Society. Mr. Woods expressed similar views. After considerable discussion, Mr. Titcomb's suggestion, as supported by Mr. Millett, of a special committee to consider the matter was unanimously adopted.

Mr. John P. Woods, of St. Louis, Missouri, was appointed Secretary pro tem.

APPOINTMENT OF COMMITTEES.

The following committees were named by the President:

Resolutions: John N. Cobb, Lee Miles, W. E. Albert, and Chas. O. Hayford.

Nominations: Wm. C. Adams, E. W. Cobb, M. L. Alexander, Dwight Lydell, and C. F. Culler.

Time and Place of Meeting: M. L. Alexander, E. W. Cobb, B. O. Webster, E. T. D. Chambers, and J. P. Woods.

Auditing: W. E. Albert, S. W. Downing, and S. P. Wires.

Program: Glen C. Leach, J. N. Cobb, B. O. Webster, and W. E. Barber.

Awards: J. W. Titcomb, W. E. Albert, Dr. E. A. Birge, J. G. Needham, J. N. Cobb, and Carlos Avery.

The session adjourned at 11 a. m.

Following the morning session at Madison the Wisconsin Conservation Commission entertained the members of the Society by a trip to the Dells. The journey was made by automobile to Kilbourn, there being a stop en route at Devil's Lake for luncheon, and by boat from Kilbourn to the Dells. On the return a visit was made to a famous Indian camping ground. A banquet was served at Kilbourn and the party returned to Madison later in the evening.

Morning Session, September 7, 1922.

The President called the meeting to order at 9:30 a. m.

REPORT OF THE TREASURER.

Boston, Mass., September 7, 1922.

To the American Fisheries Society:

Herewith is submitted the annual report of the Treasurer from the meeting in Allentown, Pa., in September, 1921, to August 2, 1922.

I know it will be very gratifying to you all to learn that the report this year is of a very encouraging nature. All bills against this Society as far forth as have been presented to the Treasurer have been paid, $666.41 in donations have been transferred to the Permanent Fund in partial repayment of the loan of last year, and the cash book at the present time shows a fair balance. Certainly it seems that the Society has some cause for congratulation here.

Present time dues have been paid quite promptly and those outstanding are less than for several years. Very old accounts have been practically cleaned up. It seems to me that these two points indicate

a real awakened interest in the continued existence of the organization. The raising of the annual dues, contrary to general expectation, does not seem to have affected the membership adversely. Indeed I believe to the raising of the dues and the payment of back dues can be attributed the fact that we have paid our bills and have a slight balance.

Just a word here in regard to paying back into the Permanent Fund the loan of last year of $2,000. It seems to me that we are progressing finely in this object. There has been a total of $666.41 paid back for this purpose, leaving an actual balance of $1,324.74 still to be replaced. At the present rate of repayment the Permanent Fund should again be intact within three or four years. It seems to me that this object can be easily attained by an annual appeal for donations following the plan instituted by former President Buller. I believe that none of us expected that the fund would be replaced entirely in one year. Indeed this would be too much to expect, but I do believe if the succeeding Presidents follow the original plan of appeal, that by 1925 or 1926 we shall have the satisfaction of seeing the Permanent Fund entirely repaid for the amount we were obliged to borrow from it in 1920. Certainly by seeking small contributions from many each year the amount can be paid up without any serious strain on anybody's pocketbook.

I feel that with the natural increase to be expected in our personal membership, expected increases in the memberships of States and Clubs and with expenses kept down within the limit to those of this year, we have every reason to expect that our financial problem will cause us less worry in the future than it has in the immediate past.

I invite your attention to the following financial statement:

Receipts

Balance in Treasury after the meeting of 1921		$726.20
Annual dues:		
Individuals:		
For the year 1919	$2.00	
For the year 1920	62.00	
For the year 1921	1,025.99	
For the year 1922	18.00	
Clubs:		
For the year 1920	7.00	
For the year 1921	225.00	
For the year 1922	5.00	
Dues, States	50.00	
Dues, Companies	10.00	
		1,404.99
Life Memberships		15.00
Donations		189.00
Sales Transactions		222.50
Interest		5.97
Exchange		.60
		$2,564.26

Disbursements

Reporting 1921 meeting	$375.10	
Literature for meetings, stationery, etc.	135.17	
Printing Transactions, meeting of 1920, Vol. L: No disbursement from general treasury. The amount of $1,991.15 was borrowed from the Permanent Fund to defray this expense.		
Printing Transactions, meeting of 1921, Vol. LI	620.83	
Donations temporarily deposited in the general fund, transferred to Permanent Fund in partial repayment of loan to pay for printing of Transactions, Vol L	666.41	
Postage	112.70	
Exchange	.63	
Services (Secretary, his assistant, and assistant to Treasurer)	450.00	
		$2,360.84
Balance per cash book		$ 203.42

Permanent Fund

Balance as reported at 1921 meeting	$1,128.84
Interest	49.72
Deposits (donations by members to reimburse the Permanent Fund for loan to defray printing bill for Transactions, Vol. L, 1920. Loan, $1,991.15; payments to date, $666.41; amount still due, $1,324.74)	666.41
Balance	$1,844.97

Respectfully submitted,

A. L. MILLETT,
Treasurer.

The report was referred to the Auditing Committee.

REPORT OF THE EXECUTIVE SECRETARY.

MR. JOHN P. WOODS presented the report of the Executive Secretary as follows:

TO THE OFFICERS AND MEMBERS OF THE AMERICAN FISHERIES SOCIETY:

As in previous years the chief feature of the work was the preparation of the volume of Transactions published annually. On account of the very heavy expense incurred in the publication of the Fiftieth Anniversary volume, and the depleted state of the Society's finances at the time of the 1921 meeting it was felt to be necessary to reduce this expense to the lowest possible figure and yet get out a volume in keeping with the aims and ideals of the Society. A great deal of time and attention

was therefore given to editing and condensing the proceedings of the Allentown meeting and the voluminous discussions of papers presented. Most careful thought was given to this matter in order always to preserve the meat of discussions while eliminating the unessential. A number of congratulatory comments have been received in respect to the volume which was published.

As soon as all copy was ready bids were solicited from a number of reliable printers. The lowest bidder was the W. F. Roberts Company, which made a rate of $3.11 per page of 10pt. matter, with certain charges for extras. The volume comprised 153 pages and contained the business proceedings, 13 special papers and discussions, and two general discussions on assigned subjects. The total cost of printing the edition of 750 copies was $620.83, or slightly less than $1.00 each. This low cost was a matter of great satisfaction in view of the need to repay at as early a date as possible the amount borrowed from the Permanent Fund of the Society to meet the indebtedness carried over from the previous year.

Efforts have been continued to secure new members for the Society, and also to sell sets of Transactions to libraries and others interested. Very satisfactory results have followed, particularly in the efforts of a number of members to secure memberships from fish and game clubs. Especially to be congratulated in this connection are former President Buller and his aids, 32 organizations within the State of Pennsylvania now being members of the Society. The Society also lists seven State commissions and 15 libraries among its members. Other libraries which are unable to become members of the Society regularly purchase the Transactions. About $250 worth of back issues of the Transactions have been sold since the last report.

Since the publication of the list of contributors in the 1921 volume the Secretary has been notified of the receipt of $50 more from Mr. M. L. Alexander.

Early in the year a special circular letter, including a blank application, was prepared for use in an extensive membership campaign, and under date of May 20, 1922, announcement of the prize competition was sent out.

The present membership of the Society is as follows: Honorary, 65; Corresponding, 9; patrons, 53; active, 565; total, 692.

WARD T. BOWER,
Executive Secretary.

The report of the Executive Secretary was adopted.

REPORTS OF VICE-PRESIDENTS OF DIVISIONS.

MR. BARBER: We will now have the reports of the Vice-Presidents of divisions.

MR. E. W. COBB, Division of Fish Culture: Mr. President, I did not prepare any written report. I kept in touch with the matter as closely as I could during the last year with the idea

of reporting progress. Strictly speaking, however, I could see very little progress in the actual work of fish culture. We have made great progress in the indirect work of fish culture; in that we seem to have a very general understanding as to many of our failings and many of our needs, a consideration which bids fair to make the work much more effective. The fish culturist has been wasting a great proportion of his work by placing the fish under conditions in which they could not live after being liberated, and in that respect we have been making an advance during the last year in many of the states and in the Federal work. We have been getting more effective equipment and a better understanding of the needs of the fish in transportation and in planting. We have been getting more help from the scientific men; there is more cooperation, I believe, among the states and between the states and the Federal Government. In other ways also the advance has been great in the past year and promises to be greater in the year to come, because we understands our needs and our limitations better than we ever did before.

MR. ADAMS, Division of Protection and Legislation: The year has been given over largely to the consideration of the further protection of migratory fish. This action has taken no definite form. The more we get into the subject the more we find that it is a big one; and there is not necessarily a conflict of interests, but there is a need for further investigation, for further study, before an adequate report can be made.

MR. WOODS: I move that these reports be accepted, and congratulate the Vice-Presidents upon making them. It is seldom that reports from these Divisions are filed, and as the practice has been initiated, I think it should be followed.

The Vice-Presidents of the Divisions of Aquatic Biology and Physics, Commercial Fishing, and Angling were not present, and no reports were received.

No reports were made by the Committees on Foreign Relations and on Relations with National and State Governments.

A paper entitled, "Protecting Migrating Pacific Salmon," was read by John N. Cobb. Discussion followed.

A paper was presented by Dwight Lydell entitled "Brief Notes on Fish Culture in Michigan." Discussion followed.

Dr. E. A. Birge presented a paper under the subject, "The

Plankton of the Lakes," following which there was extended discussion.

At 12:30 p. m. recess was taken until 2:00 p. m.

Afternoon Session, September 7, 1922.

President Barber called the meeting to order.

REPORT OF AUDITING COMMITTEE.

Your committee to which was referred the Treasurer's report begs to state that it has made a thorough examination of the books and finds them correct in every respect.

The report was duly adopted.

A letter from Mr. M. G. Sellers, Philadelphia, Pa., was read, as follows:

I regret being unable to attend the 52nd Annual meeting of the Society or present a more satisfactory report in the matter of enlisting the good offices of the American Bar Association in preparing a model statute on the subject of stream pollution, which might serve as a uniform basis of action by the various states pending Federal supervision or regulation to further strengthen same in so far as they relate to boundary waterways, etc.

I transmitted this request to the Association through a prominent Philadelphia member who has been ill for some time, and his office was unable to give me any definite information at this time as to its progress or whether it was a part of any report presented at the annual meeting of the American Bar Association held in San Francisco, Cal., August 9-12, 1922. I can, therefore, at this writing only report progress with assurance of following up, of which the Society will be duly advised.

Crystallizing public sentiment in support of corrective legislation upon this general subject has received wonderful impetus in the Atlantic Seaboard States in the formation at Atlantic City, August 9, 1922, of the National Coast Anti-Pollution League with Mr. Gifford Pinchot, the Republican nominee for Governor of Pennsylvania, as President, and while this primary effort is aimed at Congressional action in abolishing the oil nuisance, it will have a salutary effect upon the inland water problem.

A paper entitled, "Octomitus Salmonis, a New Species of Intestinal Parasite in Trout," was presented by Dr. Emmeline Moore. Discussion followed.

REPORT OF COMMITTEE ON TIME AND PLACE OF MEETING.

Mr. Alexander: Your President thought it necessary to appoint this Committee so that it could confer with the Committee of the International Association of Game, Fish and Conserva-

tion Commissioners. As you know, the two societies find it profitable to meet at the same time and in the same place. The places under consideration were New York, Quebec, Detroit, Nashville, St. Louis, and San Francisco. The Committee went exhaustively into the question and the final decision was that it would be advisable for the societies to meet next year in St. Louis. The time is left to the respective Executive Committees of the two societies. But we respectfully suggest to the Executive Commitees that in selecting the time they fix upon a little later period in the year, the latter part of September or the early days of October.

The report was unanimously adopted.

MR. BARBER: Here is an offer from the National Museum of Natural History, Paris, France, to exchange their bulletins for ours. The question is whether or not you desire to do so.

The exchange was unanimously agreed upon.

A paper entitled "Pollution of Inland Streams" was presented by M. D. Hart. Discussion followed.

Mr. E. T. D. Chambers presented a paper entitled "The Maskinongé: A Question of Priority in Nomenclature." Discussion followed.

A paper entitled "Fish Cultural Work of the Bureau of Fisheries in the Mississippi Valley" was presented by C. F. Culler. Discussion followed.

At 5:00 p. m. a recess was taken until 7:30 p. m.

Evening Session, September 7, 1922.

The meeting was called to order by President Barber.

A paper entitled "Investigations in the Preservation of Fish Nets and Lines," by Harden F. Taylor and Arthur W. Wells, was read by Mr. Taylor. Discussion followed.

Mr. E. C. Fearnow presented a paper entitled "A New and Practical Device for Transporting Live Fish." This paper was discussed at the session on the following morning.

At 10 p. m. the meeting adjourned.

Morning Session, September 8, 1922.

The meeting was called to order at 9 o'clock a. m. by President Barber.

MR. MILLETT: You will recall that in my annual report I

cited to you the condition with respect to payments back to the Permanent Fund. I pointed out that we were indebted to the Permanent Fund to the extent of something like $1,300, and I made the suggestion that we could easily pay that off in small installments by 1926. I still am of that opinion. I know you concur in the view that that money must be returned; and I simply wanted to suggest that before this meeting finally adjourns some committee should be appointed or some action taken looking to the gradual or annual decreasing of that debt we owe to ourselves.

Mr. John P. Woods, who had been acting as Secretary, was obliged to leave and President Barber appointed Mr. John N. Cobb as Secretary pro tem.

Mr. Fearnow's paper, read at the previous session, was discussed.

A paper entitled "Adjustment of Environment vs. Stocking —To Increase the Productivity of Fish Life," was presented by Ernest Clive Brown. Discussion followed.

Dr. Edward E. Prince presented a paper entitlded "Irrigation Canals as an Aid to Fisheries Development in the West."

REPORT OF COMMITTEE ON AWARDS.

Mr. Titcomb: Mr. President, the committee as named in your letter of August 21st did me the honor of making me chairman, to act with Mr. J. N. Cobb, Director of the College of Fisheries, University of Washington; Dr. E. A. Birge, University of Wisconsin; and Hon. Carlos Avery, State Fish and Game Commissioner of Minnesota.

Three classifications for prizes are set forth in the Society's circular of May 20, 1922, which will be taken up in order as follows:

No. 1. "For the best contribution on fish culture, either new or improved, practical fish cultural appliances, or description of methods employed in the advancement of fish-cultural work." One paper was presented in this class, by E. C. Fearnow. Your Committee feels that this paper calls for special or honorable mention. Submitted by the author of a similar paper presented last year, it is of great importance and has received very careful consideration. The Committee feels that the apparatus should be tested in a practical way by disinterested fish culturists before awarding a prize. It is therefore recommended that a committee of three, consisting of Messrs. Hayford, E. W. Cobb and Lydell, who happen to be now distributing fish, and possibly some volunteers who are present,

be furnished with some of these cans and given an opportunity to try them and report the results of that test to this Committee within three months, the Committee on Awards to have authority then to determine whether the paper is entitled to a prize, based upon the reports of the tests.

No. 2. "For the best contribution on biological investigations applied to fish-cultural problems," your Committee has decided that Dr. Emmeline Moore, the author of the paper on "Octomitus Salmonis, a New Species of Intestinal Parasite in Trout," is entitled to a prize. This paper has the special merit not only of adding new and important data to our meagre knowledge of fish pathology, but also of suggesting in a constructive way lines of further advance in the study of hatchery diseases.

Another paper presented is by W. M. Keil, entitled, "Biological Significance of the Smolt Period in Certain Salmonoids." It is a very interesting paper and the Committee feels that it should have honorable mention. Mr. Keil has reached the conclusion, through actual tests of planting landlocked salmon which he has been raising through successive generations in the hatchery, that they should not be planted for stocking our lakes and ponds until they have been carried a year. This same conclusion has been reached by the Commissioner of Maine, who has so much to do with salmon; and it was also the conclusion in the Lake George report, to which Dr. Birge referred. But Mr. Keil has shown the results from planting in a series of years the smaller sizes of salmon, with the returns in the catch on a certain lake; then he brings out the fact that after planting these larger fish they got a fifty per cent return in the catch of fish by anglers on that lake.

No. 3. "For the best contribution dealing with problems of the commercial fisheries." The paper on "Investigations in the Preservation of Fish Nets and Lines," by Harden F. Taylor and Arthur W Wells, excites the especial interest of the Committee. The tests of netting twine under various conditions have been thorough and exhaustive and show the perseverance and ingenuity of the authors; and we feel that they are entitled to an award.

Another paper, presented by Mr. J. H. Matthews, entitled, "Problems of the Commercial Fisheries from Producer to Consumer," is a general article on the subject, contains nothing particularly original, but is the type of paper that would make a suitable editorial in the commercial fishing papers, like the Fishing Gazette or the Atlantic Fisherman.

Your Committee respectfully recommends that this practice of awarding prizes, under the same conditions as of this year, be continued; and if the Society decides to carry out that policy it is further recommended that the circulars be issued to all members as quickly as possible. Some of these studies and investigations require a year's work, and we cannot too soon have the knowledge that the policy is to be continued sent out to all the members.

MR. MILLETT: I make the suggestion that future papers offered for award to this Society be entirely original in the sense that they have not been previously printed or compensated for

either by the Government or others; and that they remain the property of this Society to print for a period of at least six months after the award is made. I make this as a suggestion, not, of course, as a part of the report.

The report of the Committee was unanimously adopted.

REPORT OF COMMITTEE ON RESOLUTIONS.

Mr. John N. Cobb presented the report of the Committee on Resolutions as follows:

Dams in Streams.

Whereas, The building of dams in streams in connection with irrigation and power projects is proving a serious menace to our runs of anadromous fishes, especially when there have been installed unsuitable fishways or none at all, and

Whereas, We understand that there are at present pending a number of such projects, with others being mooted;

Therefore, Be It Resolved, That the American Fisheries Society in convention assembled at Madison, Wisconsin, September 6-8, 1922, requests the U. S. Reclamation Commission, and such other public officials as may have jurisdiction in such matters, to require that the problem of assisting anadromous and other fishes in getting over such obstructions, and the young in working their way back to their natural habitat in the sea, be taken up and considered along with the engineering and other problems relating to each project; and this Society promises every aid possible in solving the biological phases of the problems.

Alaska Salmon Fisheries.

Whereas, It is a known fact that the salmon fisheries of Alaska are not producing as formerly, the decline being due partly to lack of adequate regulation and partly to other causes; and

Whereas, The Department of Commerce has been attempting to meet existing conditions by the establishment of reserves in those districts most vitally affected and has already established several such, said reserves being necessary on account of the inability to secure a comprehensive fisheries code which could be readily administered and which would adequately protect these districts; and

Whereas, We understand the Secretary of Commerce has now before him a proposal for the extension of the boundaries of the Alaska Peninsula Fishery Reservation, said boundaries to be extended so as to include all the waters of Bristol Bay north to Cape Newenham in Bering Sea and in the North Pacific Ocean, those waters including Cook Inlet, Shelikof Strait and about Kodiak Island, within the areas of which at present nearly three-fourths of the red salmon of Alaska are produced;

Now, Therefore, Be It Resolved, That it is the sense of the American Fisheries Society in convention at Madison, Wisconsin, September 6-8, 1922, that we heartily endorse the creation of the reserve referred to, and

our Secretary is hereby instructed to send a copy of this resolution to the President of the United States, to the Secretary of Commerce, and to the United States Commissioner of Fisheries.

POLLUTION OF WATERS.

WHEREAS, The pollution of the sea, both within and without the three mile limit, by oil and petroleum products from boats and refineries has become a serious menace to fish life as well as to property on the beaches; and

WHEREAS, It is our understanding that an International Conference has been called for the purpose of considering means to prevent this pollution of the sea by oil products and the consequent harm to the fisheries and property;

Be it therefore resolved by the American Fisheries Society at its annual meeting held in Madison, Wisconsin, September 6-8, 1922, That this Society heartily approves of this International Conference on the oil pollution problem and sincerely hopes that some practicable plan may be worked out in the early future to remove this menace to fish life; and

Be it resolved further, That the Secretary be instructed to send a copy of this resolution to the President of the United States, the Secretary of State, the Secretary of Commerce, and the United States Commissioner of Fisheries.

POWER DEVELOPMENT IN ALASKA.

WHEREAS, There are several proposed water power developments in Alaska involving either the erection of dams for power or for pulp mills on salmon canning streams; and

WHEREAS, It is known that the Federal Power Commission is from time to time granting preliminary permits for the erection of such dams; and

WHEREAS, The development of power sites and paper mill sites is likely to result, first, in the removal of the forests on the watersheds of salmon spawning streams; secondly, in obstructing the streams by dams so as to more or less effectively prevent the ascent of salmon to the spawning beds; and, thirdly, the consequent serious pollution of such streams by the poisonous chemicals discharged by pulp mills; and

WHEREAS, It is well understood by all those who are familiar with the development of dams and pollution of streams on the Atlantic coast that they result in the rapid destruction of fish life in the streams;

Be it therefore resolved by the American Fisheries Society at its annual meeting in Madison, Wisconsin, September 6-8, 1922, That the Federal Power Commission and all other Government authorities concerned in the development of power and pulp mill sites in Alaska be advised that it is the opinion of this Society that great harm and detriment to the salmon industry in Alaska will result unless the greatest care is exercised in permitting, for any reason, the obstruction and pollution of salmon spawning streams in Alaska; and

Be it resolved further, That the Secretary be instructed to forward a copy of this resolution to the President of the United States, to the Secre-

tary of Commerce, to the United States Commissioner of Fisheries, to the Secretary of the Alaska Inter-Departmental Board, and to the Secretary of the Federal Power Commission.

PUBLIC SHOOTING GROUND GAME REFUGE BILL.

Resolved, That the American Fisheries Society, whose membership is composed of scientists, sportsmen and conservative officials of North America, in annual convention assembled at Madison, Wisconsin, September 6-8, 1922, declares unanimously that the so-called Public Shooting Ground Game Refuge Bill (S. 1452-H. R. 5823) now pending in Congress is a measure in the interest of wild life conservation, and we recommend the early passage of this bill.

MADISON MEETING.

WHEREAS, The Society has had a most enjoyable meeting in the city of Madison, Wisconsin, and this has been due largely to the efforts of the following organizations and individuals: The Wisconsin Department of Conservation (and especially to Messrs. W. E. Barber, B. O. Webster and C. L. Harrington) which had general charge of arrangements for the comfort and entertainment of the delegates; Hon. John J. Blaine, of Wisconsin, for welcoming the Society through his representative; the Madison ladies, and especially Mrs. W. E. Barber and Mrs. B. O. Webster, who did so much to make the visit of the ladies accompanying the members an occasion long to be remembered; the State Highway Commission; Dr. Sam Chase, President of the Four Lakes Rod and Gun Club; the individuals who furnished automobiles and chauffeurs for delightful trips in and around Madison;

Resolved, That the most sincere thanks of this Society be extended to all the above.

OFFICERS.

WHEREAS, The high executive ability of the retiring President Mr. W. E. Barber; the secretarial ability of our temporary secretary, Mr. John P. Woods; and the efficiency of Mr. Arthur L. Millett, treasurer, have contributed much to the smoothness of operations during the sessions and to the comfort of the members;

Be it therefore resolved, That a vote of thanks be hereby extended to the officials named above.

TRIBUTES TO DECEASED MEMBERS.

GEORGE H. GRAHAM: During the past year the Society has suffered the loss of two of its most distinguished and useful members.

Indefatigable worker and born optimist, George H. Graham, of Springfield, Massachusetts, was endowed by nature with the spirit of a true sportsman and conservationist. To him the skies were always blue and clear; the wind always fair; to him all men were friends. Large of heart and noble of character, he attracted to his coterie of intimates, kindred spirits. He was a true type of those men who visualize ideals and strive to press forward to their attainment, yet always with kindly and con-

siderate regard for the rights and feelings of others. Gone from us—"passed on to silence and pathetic dust"—the spirit of George H. Graham, returning to God who gave it, remains an inspiring lesson to those of us who knew him personally and so well, who are striving to continue the work he loved; who feel indeed that he is not gone, but "just around the corner." The American Fisheries Society has suffered a great loss, but the inspiration of his optimism will remain for a long time to come. Let this brief and imperfect tribute be spread upon the records of the Society as a memorial to our departed associate, and a copy thereof sent to the members of his immediate family as an expression of our sincere sympathy.

JAMES NEVIN: James Nevin of Wisconsin was one of the pioneers in fish culture in the United States. He devoted his entire life to his chosen profession and achieved distinction and renown. For forty years he served his state and developed its fish cultural work from the most primitive beginnings to one of the most successful and extensive systems in the entire country. The records of this Society abound in his contributions to the practical knowledge of fish culture. Mr. Nevin was not only a faithful and efficient public servant; he was a loyal friend, a genial and considerate associate, an upright citizen. His character was of that staunch and sturdy nature which is all too rare. "Jim" Nevin's word was as good as his bond; he was generous, unselfish, helpful and considerate to those in his employ and with whom he was associated. He was honored by the Governor of his State and respected by his fellow-citizens to the last days of his useful life. This Society keenly feels his loss and misses him from its councils. We of this Convention extend to his former associates on the Wisconsin Conservation Commission, to the citizens of his State, and to bereaved relatives, this expression of condolence.

MR. HENRY O'MALLEY, Commissioner of Fisheries, Washington, D. C.: I should like to say a word, Mr. President, with regard to the second resolution presented by the Chairman of the Committee, dealing with the salmon fisheries of Alaska. Last winter the Department of Commerce established a reservation taking in a portion of the Alaska Peninsula. By the introduction of the purse seine into the waters which the proposed reservation covers, there is a possibility of the red salmon fisheries of the Bering Sea being destroyed. At present the Department of Commerce has jurisdiction only five hundred yards outside the mouths of the streams. By the method of fishing that was adopted this year, the purse seiners go out beyond the limits of the gill nets and with one haul of their purse seines, catch two or three scow-loads of salmon. Such methods as this are what we are desirous of controlling; and by the Presidential Proclamation, as contemplated, we shall have the necessary authority to regulate the entire fishery.

I think it is very important that this resolution receive the support of this Society.

MR. TITCOMB: Mr. President, bearing upon the resolutions respecting the death of members of the Society, I would simply like to mention here one who has passed away since our last convention, and who took a very active part in welcoming and entertaining those in attendance at the meeting in Allentown. I refer to Mr. H. A. Grammes, of whose death I learned only a short time after the conclusion of our last year's meeting.

On motion of Mr. J. N. Cobb the report of the Resolutions Committee was unimously adopted.

MR J. N. COBB: One of the members has submitted the following proposal:

It is moved that the American Fisheries Society invite the National Association of Fisheries Commissioners to send to the St. Louis, Mo., meeting of the American Fisheries Society delegates for the purpose of arranging terms upon which affiliation may be consummated; and that the President of the Society instruct the Secretary to communicate this invitation.

The motion was carried unanimously.

REPORT OF COMMITTEE ON NOMINATIONS.

Mr. J. N. Cobb presented the report of the Committee on Nominations, as follows:

President—GLEN C. LEACH, Washington, D. C.
Vice-President—GEORGE C. EMBODY, Ithaca, New York.
Executive Secretary—WARD T. BOWER, Washington, D. C.
Recording Secretary—THOMAS E. B. POPE, Milwaukee, Wisconsin.
Treasurer—A. L. MILLETT, Boston, Massachusetts.
Vice-Presidents of Divisions:
Fish Culture—CHARLES O. HAYFORD, Hackettstown, New Jersey.
Aquatic Biology and Physics—DR. E. A. BIRGE, Madison, Wisconsin.
Commercial Fishing—GARDNER POOLE, Boston, Massachusetts.
Angling—JOHN P. WOODS, St. Louis, Missouri.
Protection and Legislation—H. W. VICKERS, Baltimore, Maryland.
Executive Committee:
EBEN W. COBB, Chairman, St. Paul, Minnesota.
JOHN W. TITCOMB, Hartford, Connecticut.
EDWARD E. PRINCE, Ottawa, Canada.
W. E. ALBERT, Des Moines, Iowa.
GEORGE SHIRAS, 3D, Washington, D. C.
JOHN N. COBB, Seattle, Washington.
Committee on Foreign Relations:
FREDERIC C. WALCOTT, Chairman, Norfolk, Connecticut.

M. L. ALEXANDER, New Orleans, Louisiana.
W. C. ADAMS, Boston, Massachusetts.
R. E. FOLLETT, Detroit, Michigan.

Committee on Relations with National and State Governments:
NATHAN R. BULLER, Chairman, Harrisburg, Pennsylvania.
W. L. FINLEY, Jennings Lodge, Oregon.
E. T. D. CHAMBERS, Quebec, Canada.
A. L. MILLETT, Boston, Masschusetts.
MAX D. HART, Richmond, Virginia.

The Secretary was directed to cast one ballot for the Society, and the respective officers were declared elected for the year 1922-23.

MR. TITCOMB: I hope that a campaign can be waged between now and the next meeting to get the various fisheries commissioners to attend the meetings of the American Fisheries Society which, I assume, will in 1923 precede the meeting of the International Association of Game, Fish and Conservation Commissioners. Also I should like to see some action taken—whether it needs official action or not I do not know—to attempt to wipe out our debt. I am ready to subscribe this year the same amount I subscribed last year to help relieve that burdensome condition.

MR. MILLETT: I had it in mind to suggest that the incoming President be chairman of a committee to work with the Executive Secretary and the Treasurer to formulate plans covering the matter during the year. I have in mind an idea whereby we will be able to make a fairly satisfactory report next year.

President-Elect Leach assumed the chair amid applause.

MR. LEACH: Fellow members, I wish to thank you for the honor you have conferred upon me by selecting me as President of the American Fisheries Society. I feel it is a privilege to represent such a distinguished body, especially when I look back over the history of the Society and realize that this position has been filled by many eminent members.

I hope that at our next meeting in St. Louis, which I consider my native town, you will present some of your problems, or give us a paper on some important phase of your work. I also hope that each one of you will endeavor to bring another member or present the names of persons as new members of the Society. Extend to the various commercial fishermen, fisheries associations, clubs and others, an invitation to attend the meeting, and work with your own state fish commissioners and endeavor to get them to come to the meeting and take an active part in it.

MR. BARBER: I want to say to the members of the American Fisheries Society that it was indeed a pleasure to your president of the past year and to his associates of the Conservation Commission of Wisconsin to have had the privilege of entertaining this Society, and we sincerely hope you will go back to your homes with pleasant recollections of your visit here.

MR. LEACH: I think the members of the Society have enjoyed Madison very much, and on behalf of the Society I wish to thank the Wisconsin Fish and Game Commission for their very elaborate and generous entertainment of the members during our stay in this city.

MR. J. N. COBB: I should have made this announcement on the first day of our meeting, but I overlooked it and Mr. Barber failed to remind me of it. Most of you will remember that in 1914 we organized the Pacific Fisheries Society, modeled after the American Fisheries Society, and established because we are so far away from the scene of operations that we are but rarely able to attend its meetings, only one of which has ever been held on the Pacific Coast. Our local society covers the States of California, Oregon, Washington, Montana, Idaho and Utah, and the Province of British Columbia. At the meeting held on August 24, they elected me for the second time President of the Society, and I was instructed to extend the heartiest greetings of our Society to the American Fisheries Society. We feel sure that the especially cordial relations that have existed between us in the past will continue in the future.

MR. BARBER: Mr. Henry O'Malley, who has recently been appointed United States Commissioner of Fisheries is here, and I am sure we would all like to hear from him.

MR. O'MALLEY: Mr. President and members of the American Fisheries Society: I am very glad indeed to have the opportunity of being present at this meeting, even if it is only during the closing hours. I am very sorry I could not be here throughout the entire session. I have been making a trip through the south and to the west coast, taking up matters in which the Bureau is interested, and I am now on my way back to Washington.

I feel that these meetings bring closer cooperation between the State fisheries and the Bureau; it is very important that there be the closest harmony. In other words, I feel like the Irishman when he was commenting upon the aeroplane. Pat and Mike were walking along together and there was an aeroplane overhead. Pat said

to Mike, "Mike, I wouldn't like to be up there in that aeroplane." "Sure," said Mike, "an' I wouldn't like to be up there without it!" It is true that the Federal Government and the State authorities must work together in order to secure the best results. Particularly is that the case when it comes to the distribution of fishes throughout the country. The Bureau has only a limited knowledge of the various waters of the States, and there is a chance of some applicant requesting fish, the introduction of which might be destructive to the fish indigenous to the streams. Therefore I wish to ask the State Fish Commissions not to hesitate at any time to write the Bureau on this subject. In many cases the Bureau is referring applicants to the State Fish Commissions in order that requests may be passed upon by the local officials; thus the burden of responsibility will rest upon the State if we make a mistake.

I do not believe this is an appropriate time to take up the two subjects that are really burninig issues today, because I presume they have been discussed earlier in your meeting. I refer to the questions of pollution, and to the establishment of fishways in the various streams where dams are built or proposed. In the east the dams have already been constructed, and in some instances fishways have been provided. On the Pacific Coast big power projects are coming to the front; this year alone in southeastern Alaska there have been sixteen applications for the damming of streams known to be among the very best salmon streams in that country. If all these permits are granted it means the annihilation of the salmon industry of Alaska. A hydro-electric power enterprise wishes to dam the Klamath River for the development of power. They guarantee the expenditure of thirteen millions and the creation of a permanent industry in northern California. This river supports a fishery worth annually about $120,000; so you can see the condition that exists with respect to that one case alone. As I view the matter, it is good policy for the people who are interested in the fisheries side of the work to get in with these people and try to arrive at a solution of the problem if possible; otherwise—at any rate this is the case with us on the coast—our salmon stands a chance of being exterminated. In Alaska, where some of these projects are under consideration, the salmon fishery is of first importance, because Alaska without its salmon would be a very poor country. Perhaps many of you do not know that at the present time about 78 per cent of the running expenses of the territory of Alaska are paid by the taxes

imposed upon the salmon canning industry, but not one cent of the tax goes to the rehabilitation of the fisheries.

I am very glad to have had this opportunity of speaking to you for a few moments. I ask you all for your heartiest cooperation with the Bureau.

MR. LEACH: This Society can be a very important medium for the elimination of differences between State Commissions and the Bureau of Fisheries. For that reason I am very anxious to have the State Commissioners meet with us next year in St. Louis so that we can discuss these various problems. If we who are interested in these matters meet personally and discuss these various points of interest, little difficulties can be smoothed out and relations established that will be useful not only to the persons concerned but will add to the efficiency of both the State and Federal organizations.

MR. AVERY: Would it not be desirable, in view of what Mr. Leach has just said, and of what others have said in the last few minutes, that the program of the next meeting of the Society be made up with reference to that very thing? In preparing the program for next year, could there not be incorporated some subjects that would be of special interest to the State Commissioners and that would result in getting and keeping more of them at the sessions of the Society's meetings?

MR. LEACH: I consider the sessions of the American Fisheries Society a meeting point where the layman and the scientist can get together and discuss their problems in a broad way. Many of the fish commissioners are appointed for a limited period of time and it is necessary for them to be educated as expeditiously as possible in the best methods of handling their organizations. Anyone can attend our meetings and come in contact with men who have worked up from the ranks; he can meet scientists and practical men interested in the everyday problems of fish culture.

PROF. E. E. PRINCE, Commissioner of Fisheries, Canada: Mr. President, I feel that I have already trespassed a great deal on the time of this convention. I am sorry that we do not have a larger representation from Canada at these meetings, but through the published transactions we get a great deal of benefit—though the personal contact to which Mr. Leach has alluded is undoubtedly most beneficial and stimulating.

Instead of referring particularly to our work in Canada I

would like to bring out another point which I will place briefly before the convention. Fish Commissioners from various states and from the provinces of Canada should make it a point to be present and come in contact with other officials and scientists who gather at these annual conventions for discussion and mutual benefit. But I have often felt that the communities in which the Society meets have not realized always that an important convention was proceeding in their midst; and they have not realized until the meeting was over that the consideration of matters of vital interest to then has been going on. I do not say that is the case in Madison, but it has occurred in some of our conventions. I think that the contact of the Society with the public should be emphasized; that there should be evening meetings with possibly one or two popular addresses, perhaps illustrated by slides or pictures, to which the public should be invited. I think that would do good. I venture, therefore, to throw it out as a suggestion worth considering whether one or two evenings during our convention should not be devoted to something like a public gathering. There might also be an exhibition of apparatus or of specimens which would be of interest.

MR. LEACH: I think that is an excellent suggestion. We could have lantern slides or motion pictures showing the fish-cultural work and the problems with which we have to contend, and display them at a meeting to which the public should be invited.

MR. J. N. COBB: I think the suggestion is good that during the course of the convention a popular lecture be arranged, illustrated by lantern slides or motion pictures. That ought to be one of the first features of the program to be arranged; then there would be ample time to advertise it. I am sure there are members here who would be willing to assist. I would be only too glad to contribute from our stock of lantern slides, and we have a vast number, many of which would probably be interesting.

MR. LEACH: I am very much pleased to hear you say that Mr. Cobb. I will make note of it. Perhaps Dr. Prince will also bring something from his country which will be of interest to us. I understand also that Mr. Titcomb has something he could give us.

Adjourned sine die.

In Memoriam

M. L. ALEXANDER

J. C. BELL

HOWARD EATON

GEORGE H. GRAHAM

OSCAR GRIMM

JAMES NEVIN

G. H. RICHARDS

BARON N. DE SOLSKY

CALVERT SPENSLEY

GRANT E. WINCHESTER

J. H. WESTERMAN

PART II

PAPERS AND DISCUSSIONS

INVESTIGATIONS IN THE PRESERVATION OF FISH NETS AND LINES.[1]

By HARDEN F. TAYLOR
Chief Technologist
and
ARTHUR W. WELLS
Assistant Technologist, Bureau of Fisheries, Washington, D. C.

INTRODUCTION.

In a paper by one[2] of us, the literature dealing with the preservation of fish nets was reviewed and summarized. The method which appeared best where tar could not be used was that of Bull, which consisted of a bark extract applied hot, and mordanted with potassium bichromate and a small amount of copper sulphate. Reference may here be made to a series of papers which escaped notice in compiling that review, namely the Dutch investigations carried out in the years from 1915 to 1920 by Van Dorp, Tombrock and Olie.

The Dutch papers deal principally with tanning materials for use in net preserving, and also with the use of aniline dyes for giving a desirable color to fishing nets and lines. They contain data on a great variety of tanning materials obtained from many localities in various parts of the world. Perhaps the most important result of these investigations is the demonstration that if an ammoniacal solution of copper sulphate is used instead of potassium bichromate to mordant or fix the tanning material in the line, much better results are to be had. The chemical reason assigned for this superiority is that the presence of ammonia prevents any injury from acid that would otherwise be set free, and also that copper has a preservative effect on the line. This method of treating lines, recommended by the Dutch Fishery Experiment Station, is hereinafter referred to as the Dutch method.

The significant fact is that while some investigations have been made, and valuable results obtained, the preservation of nets is still crude; extensive and thorough study is much needed, espe-

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[1] This paper was awarded a prize of $100 for the best contribution dealing with problems of the commercial fisheries.

[2] Taylor, Harden F. Preservation of Fish Nets. Report of the U. S. Commissioner of Fisheries for 1920, Appendix IV, 35 p. Separately printed as Doc. 898, U. S. Bureau of Fisheries, Washington, D. C., 1921.

cially studies directed toward the development of new preservatives, and toward the definite elimination of those which can be shown to have little or no value.

Accordingly, after the review of literature above referred to was completed, an investigation of net preservatives was undertaken in the summer of 1920; this investigation has been pursued and is still being pursued on an increasingly extensive scale, so that thousands of tests have been made of many preservatives on both cotton and linen thread, in salt water in various latitudes, at different temperatures, and in fresh water of the Great Lakes. This paper will report, in somewhat abridged form, the more important results of the work, but for lack of space will be limited to the work of cotton lines. What was perhaps the greatest obstacle to rapid progress was the lack of reliable technique of testing the samples before and after exposure, a lack which is not only evident on examination of the literature, but also borne out in private correspondence with the Director of the Dutch Laboratory at Utrecht, Dr. J. Olie, who states that technique of testing is the greatest need. Accordingly, much attention has been given to this important aspect of the subject, and instruments for and methods of testing have been devised, tried, improved and adopted.

PRELIMINARY EXPERIMENTS.

By way of a beginning, a small series of lines was tested in 1920. The thread used was No. 24 white cotton cord. The treatments were (1) Bull's method, quercitron, mordanted with potassium bichromate and copper sulphate; (2) impregnation of lines with copper ferrocyanide by treatment with approximately N/10 copper sulphate, followed by potassium ferrocyanide; (3) same as (2) but potassium ferrocyanide was applied first; (4) same as (2) but N/2 solutions were used instead of N/10; (5) solution of Ivory soap followed by solution of copper sulphate, both solutions at 75° C., when applied; and (6) white lines, no treatment. No. 5 is a method used by French sardine fishermen, and since it deposits an insoluble copper soap on the lines, appeared to deserve more study than it had hitherto received. Two examples were prepared by each method, and were placed in sea water at Beaufort, N. C. One sample of each was removed at the end of four weeks, the other ten weeks. The breaking strength was ascertained with the following results:

TABLE I.—BREAKING STRENGTH OF LINES.

Number	Method of treatment	Strength after 4 weeks	Strength after 10 weeks
		Kg.	Kg.
1	Bull's method (quercitron, etc.)	13.40	7.78
2	N/10 Copper sulphate and N/10 potassium ferrocyanide	10.86	3.66
3	N/10 Potassium ferrocyanide and N/10 copper sulphate	10.62	3.22
4	N/2 Copper sulphate and potassium ferrocyanide	13.06	4.98
5	Ivory soap and copper sulphate	11.96	7.32
6	Untreated, control	10.48	1.18

Bull's method here proved to be best, as a preservative of breaking strength under the conditions described. Next in order is the soap-copper combination. The failure of the copper ferrocyanide lines was obviously due to faulty impregnation, since the inner strands of the cord were not reached by the preservatives.

Copper soap appeared to deserve further study. Microscopic examination of the fibers showed that the copper soap was not uniformly deposited, but was in the form of an amorphous precipitate. Experiments were next undertaken to effect a better penetration of the fibres and a more uniform distribution of the copper soap by means of a suitable solvent. Ivory soap, and the copper soap made from it, is a mixture of various fatty acid salts; copper stearate was found to be insoluble in any ordinary solvent, but the oleate is soluble in benzol, gasoline, carbon tetrachloride, turpentine, and various oils. The solution of copper oleate in benzol or gasoline penetrates cotton lines readily, and on evaporating, leaves a uniform deposit of copper oleate on, and possibly in, the fibres.

One of the difficulties at first encountered with copper soap was its tendency to creep to the surface of the line on drying. It was found, however, that the presence of a small amount of non-volatile mineral oil in the benzol solution serves largely to prevent this creeping. When gasoline is used as a solvent, the small quantity of a fraction of high boiling point present helps to prevent this creeping.

METHODS USED AND PRESERVATIVES STUDIED IN PRESENT EXPERIMENTS.

The work so far described was of a preliminary nature; it

served to point the way to further work, and to indicate the nature of the difficulties to be encountered. Accordingly, plans were made to carry out several large series of experiments, involving the preparation, exposure in the water and testing of several hundred individual samples treated by all the ordinary proprietary and non-proprietary preservatives available. Since the tests were repeated in many cases fifty or one hundred times in order to get a fair average of results, many thousands of tests were made. The samples were made in sets of seven by each method, one to be held as a check, and the six to be taken up from the water at intervals of three weeks to two months, the test usually running six months. Most of the exposures hitherto made in the European experiments have lasted less than two months. By way of describing these experiments, the results will be presented in connection with the different factors concerned and the methods of measuring them.

The work was limited to (1) those non-proprietary preservatives that are in widespread use or have been known by investigation to be superior as net preservatives; (2) copper oleate as a promising prospect for a new preservative; and (3) all proprietary net preservatives on the market or in preparation for exploitation. These latter were obtained by means of circular letters sent through the various fishery trade journals.

1. Control.

A. White line, no treatment.

2. Non-proprietary Preservatives.

Tar.

F. Coal tar, distilled. Black, thick, syrupy tar. Applied cold, diluted with an equal volume of benzol. The benzol evaporates from the lines.

G. Pine tar. The commercial article, consistency of thick syrup. Brownish black. Applied cold, diluted with an equal volume of benzol. The benzol evaporates from the lines.

H. Coal tar 1 volume, pine 1 volume, benzol 2 volumes. Applied to the lines cold. When the benzol has evaporated, equal parts of the two tars remain on the lines.

Tanning Methods:

I. Bull's method. A 20 per cent solution of solid extract of quercitron in water is prepared, and heated nearly to boiling. The line is steeped in the hot decoction until the latter is cold, then taken out and dried. The line is given the same steeping a second time, dried, and finally mordanted with a 3 per cent solution of potassium bichromate. (For

details, see Taylor, 1921). The copper was omitted from the formula so as to get a check on the value of copper in connection with tanning extract.

L. Dutch method. The lines were steeped twice with hot extract of quercitron, drying each time as in the foregoing, and mordanted with an ammoniacal solution of copper sulphate, containing 1 per cent copper sulphate and 3 per cent of a 28 per cent solution of ammonia. (See Olie, J., Jaarverslag van het Visscherij-Proefstation over 1917, subtitle, Voorschriften voor de behandeling van netten met kopersulfaat en ammonia, p. 40-42, 1917.)

Copper Oleate:

B. Copper oleate approximately 7 per cent solution in gasoline. The lines so treated contained about 8 mg. copper per yard.

C. Copper oleate. About 7 per cent copper oleate solution in gasoline, 5 per cent mineral oil, to prevent the copper oleate from "creeping" to the surface, and cresol, 1 to 1,000. The line so treated contained about 8 mg. copper per yard.

D. Copper oleate, approximately 11 per cent solution in gasoline. The line so treated contained about 11 mg. copper per yard.

E. Copper oleate, approximately 11 per cent solution and 2 per cent mineral oil, in gasoline.

M. Copper oleate, a solution of about 7.5 per cent copper oleate in gasoline. Line contained 8 mg. copper per yard.

N. Copper oleate, approximately 12.5 per cent solution in gasoline, with 5 per cent mineral oil and 1-1,000 cresol. The line contained 12 mg. copper per yard.

O. Copper oleate, approximately 12.5 per cent in gasoline. The line contained 18 mg. copper per yard.

P. Copper oleate, approximately 12.5 per cent in gasoline, and 2 per cent mineral oil. The line contained 18 mg. copper per yard.

3. PROPRIETARY PRESERVATIVES.

J. Petroleum Product No. 1, a preparation made by a petroleum product company. Original formula. Dark, brownish black liquid, thinner than the coal tar. Lines dipped and dried.

X. Petroleum Product No. 2, similar to J, but a later formula supplanting Petroleum Product No. 1. In appearance similar to J. Line dipped and dried.

K. Waterproofing material, a preparation made by a manufacturer of waterproofing materials.

Q. Copper paint No. 1, a coppery colored paint, similar to that used to protect the bottoms of ships. It was diluted with an equal volume of creosote oil (according to directions), and the lines were dipped in it and dried. The treated lines contained 60 mg. copper per yard.

R. Copper paint No. 2, similar in appearance to the foregoing. The treated lines contained 270 per cent mg. copper per yard.

S. Gilsonite or Uintaite, a mineral asphaltic or bituminous substance put up by a varnish company. A thick, black, tarry substance.

FACTORS WHICH MADE UP THE QUALITY OF LINES, AND METHODS OF MEASURING THEM.

Merely to subject lines to the action of water with no more definite means of testing them than a visual examination afterward, with perhaps a measurement of breaking strength, would be quite insufficient for the purpose of judging the several effects of preservatives. A cotton or linen line has numerous properties or qualities which make it suitable for fish nets. These properties or qualities must be separately measured as accurately as possible, and any changes in them during exposure to working conditions quantitatively determined. It is therefore necessary to resolve the quality of a line into its several factors, and to consider how these may be measured. It was in this field where the greatest difficulty was encountered, as methods of measuring these factors had to be devised, machines invented, made, and tested.

The factors of importance in the present connection are (1) breaking strength; (2) resistance to mechanical wear or abrasion; (3) stiffness of the line as affected by the preservative; (4) shrinkage caused by the application of the preservative; (5) increase in weight caused by the application of a preservative; and (6) color imparted by the preservative. These factors will be discussed separately. Such matters as cost, and labor in application of the several preservatives, will be considered elsewhere.

BREAKING STRENGTH.

This factor is, of course, the force or pull required to break the sample of line. It is measured on a tensile strength testing machine; the one used for the present work was a "Scott" machine at the U. S. Bureau of Standards, which Bureau cooperated with the Bureau of Fisheries in doing this part of the work. The machine is little more than a pair of fasteners which are attached to each end of the sample which is 8 or 10 inches long, and a mechanism for producing a pull which is exerted slowly on the sample by means of an electric motor. As the pull increases, a weight is lifted on a pendulous lever until the sample breaks. When the line breaks, the lever with weight is stopped in its position, whereupon a reading is taken which shows the force in pounds required to break the sample. As the jaws pull

on the sample, if the sample does not stretch, the distance between the jaws remains constant; if any stretch occurs, the jaws move away from each other, and this motion is transmitted to a sheet of cross section paper by which means is recorded the up-and-down movement or ordinates, representing stretch. At the same time the motion of the weight lever is transmitted to move the pen, causing to be recorded the horizontal component of the line, which is the abscissa. Thus the machine not only

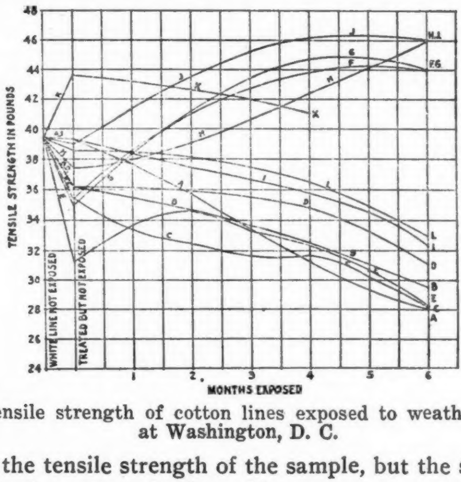

Fig. 1.—Tensile strength of cotton lines exposed to weather conditions at Washington, D. C.

measures the tensile strength of the sample, but the stretch, and records both, automatically. The measurements of tensile strength were made in a room of constant temperature and constant humidity.

The tables and graphs reproduced herewith give the results of the tensile strength tests so far obtained in the various series.

EXPERIMENTS ON EFFECT OF WEATHER (AIR CONDITION).

Fig. 1 represents the results (given in Table II) of the series which were placed on the roof of the Fishery Products Laboratory in Washington. As regards what happened to the tensile strength of the lines in the long run, the results fall easily into two groups, those preserved with tar, (F, G, H) and Petroleum Product No. 1 (a proprietary preparation) on the one hand; and white lines, those preserved with copper oleate, Bull's method and the Dutch method on the other (B, C, D, E, I, L). Water-

proofing material (K), another proprietary preparation, does not seem to fall into either group. These groups are averaged in Fig. 2 for ease in interpretation. A simple and striking conclusion stands out, namely, that those preservatives which have a "body," or a non-volatile component which covers the fibres and protects them mechanically, afford good preservation against weather, while those which do not have a body, but depend on toxic effects are not so good. Preservatives under air conditions, or weather, therefore appear to do their work mechanically or chemically rather than biologically (by destroying living organisms). Simple covering protects the lines against the weather—any preservative that covers, answers the purpose as far as tensile strength is concerned.

Table II.—Tensile strength in pounds of No. 24 cotton lines exposed on the roof of the Fishery Products Laboratory, Washington, D. C., November 25, 1921, to May 25, 1922.

One sample of each taken up each month. Each figure represents the result of 15 breaks, except that of the control (A), unexposed, which is the average of 60 tests.]

Symbol	Treatment	Tensile strength						
		Before exposure	After exposure, months					
			1	2	3	4	5	6
A	White line	39.3	37.3	36.3	33.8	31.4	27.5	28.0
F	Coal tar	35.4	43.5	36.9	44.0	46.1	43.1	44.0
G	Pine tar	35.2	39.6	39.8	44.7	47.0	44.1	44.0
H	Coal and pine tar, equal parts	37.4	38.2	37.0	41.6	43.3	43.0	46.0
I	Bull's method	39.3	40.0	36.6	35.7	36.2	36.6	32.4
B	Copper oleate 7% solution	36.1	35.3	35.0	34.0	31.9	31.9	29.6
C	Copper oleate 7% solution; 5% oil; 1–1,000 cresol	35.5	34.0	33.4	33.2	31.6	31.1	28.2
D	Copper oleate 11% solution	36.1	36.5	36.1	35.3	35.8	34.4	31.1
E	Copper oleate 11%, 2% oil	31.4	33.8	33.8	33.2	33.8	31.2	28.4
J	Petroleum Product No. 1	39.0	41.4	44.0	45.7	46.4	47.0	46.0
K	Waterproofing material	43.7	43.5	41.8	42.8	41.0	......	.....
L	Dutch Method 22 mg. copper per yard	38.6	37.6	39.0	37.6	36.2	36.0	33.0

Experiments at Key West, Florida. The lines exposed in

ocean water at Key West, Florida, from November to May, showed characteristics quite different from the foregoing. The tensile strength of these 11 samples prepared with different preservatives are shown in Table III and graphically in Fig. 3. Here, the preservatives, except the Dutch method, fall into three

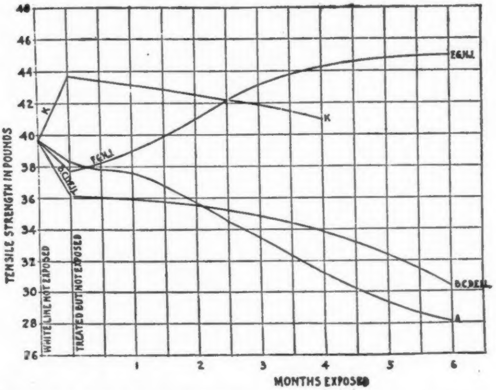

Fig. 2.—Tensile strength of cotton lines exposed to weather conditions at Washington, D. C. Grouped.

distinct classes (see Fig. 4) as follows: (1) Coal tar, pine tar, and those two tars mixed (F, G, H) show a preliminary drop in tensile strength, followed by a marked increase, which is held almost constant to the end of the period of exposure (18 weeks). (2) All those preserved with copper oleate, with or without oil and cresol, wherein an initial sharp increase in strength is followed by a constant tensile strength through the period of exposure. Both the tars and copper oleates show excellent preservation. (3) Bull's method, Petroleum Product No. 1, and waterproofing material show no particular preserving action at all, as they run essentially the same as the untreated lines. The Dutch method (L) shows characteristics which resemble, in some respects all the other three, and is therefore plotted separately.

In sharp contrast to the effect of weather conditions in the air at Washington, the lines exposed in sea water at Key West show clearly that toxic preservatives are important and consequently we must conclude that the impairment of the lines in sea water is traceable largely to biological causes. The tars

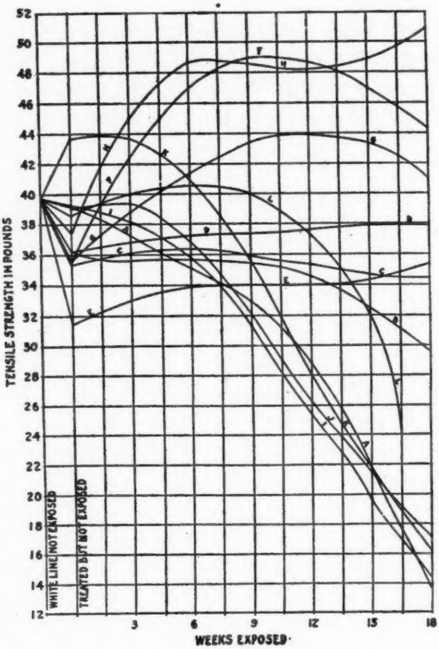

Fig. 3.—Tensile strength of cotton lines exposed to sea water at Key West, Florida.

which contain a protecting body and toxic creosote are effective; the toxic copper oleate is effective; the Dutch method, containing as it does, copper, is effective; the others, Bull's method, waterproofing material and Petroleum Product No. 1 (the two latter are bituminous or tarry, but appear to contain no toxic properties), have no preserving properties, as far as tensile strength is concerned.

TABLE III.—TENSILE STRENGTH IN POUNDS OF NO. 24 COTTON LINES PUT DOWN IN THE SEA AT KEY WEST, FLORIDA, NOVEMBER 7, 1921.

[One of each was taken up each 3 weeks over a period of 18 weeks. Each figu are is hetverage of 15 tests, except A, the unexposed and untreated ocntrol, which is the average of 60 breaks.]

Symbol	Treatment	Tensile strength, in pounds						
		Unexposed	Exposed, weeks					
			3	6	9	12	15	18
A	White line	39.3	37.3	34.3	35.0	29.3	26.2	13.7
F	Coal tar	35.4	43.2	51.0	50.2	47.8	49.6	44.4
G	Pine tar	35.2	43.9	38.9	44.8	44.2	47.0	41.0
H	Pine and coal tar, equal parts	37.4	52.2	53.0	44.0	50.1	46.0	51.0
I	Bull's method	39.3	36.1	40.6	31.7	25.1	17.6	14.4
B	Copper oleate 7% solution	36.1	34.7	35.1	36.6	35.0	33.4	29.6
C	Copper oleate 7% solution; 5% oil; 1–1,000 cresol	35.5	32.4	41.5	34.5	34.1	35.8	34.5
D	Copper oleate 11% solution	36.1	37.6	37.4	36.6	37.9	37.9	37.9
E	Copper oleate 11% solution; 2% oil	31.4	35.0	33.9	33.5	34.4	34.3	35.4
J	Petroleum Product No. 1	39.0	40.6	34.0	31.0	27.9	19.7	17.0
K	Waterproofing material	43.7	48.9	42.0	36.6	27.1	20.5	16.2
L	Dutch method	38.6	41.4	41.1	40.7	39.0	36.3	24.4

By way of demonstrating the effectiveness of copper in the lines, the reader is asked to compare Bull's method with the Dutch method. Bull's method is bark extract, quercitron, applied to the line, and mordanted by oxidation with potassium bichromate. The original formula calls for a small amount of copper sulphate, but this was omitted so as to have a control on the effect of copper. The Dutch method is the same bark extract (quercitron), mordanted with ammoniacal copper sulphate instead of potassium bichromate. The line treated by the Dutch method contains copper tannate, those treated by Bull's method contain no copper. In Fig. 3 compare lines I and L.

Experiment at Beaufort, N. C. Fig. 5 shows the results (given in Table IV) of experiments at Beaufort, N. C., February 15 to August 15, 1922. In this series, fourteen preservatives and a control were exposed as follows: (A) White line, control, (F,

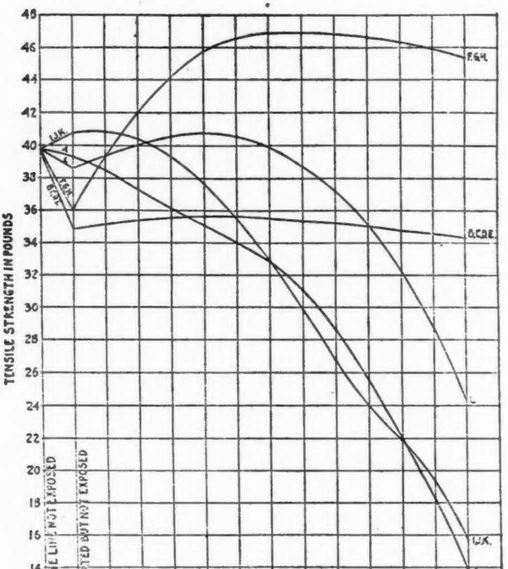

Fig. 4.—Tensile strength of cotton lines exposed to sea water at Key West, Florida. Grouped.

G, H) the three tars; (I) Bull's method; (J) Petroleum Product No. 1; (L) Dutch method; (M, N, O, P) copper oleate in four variations; (Q, R) two commercial copper paints recommended as net preservatives; (S) Gilsonite; and (X) Petroleum Product No. 2, a new formula under the same name as (J). Of these A, F, G, H, I and J are the same as were used at Key West and in Washington. M, N, O and P, while still copper oleate, were not of exactly the same concentrations as those formerly used; Q and R, the copper paints, are here studied for the first time. S, Gilsonite, a proprietary preservative and X, the Petroleum Product of new formula, are here first studied. Here again the preserved lines fall into five groups, which are shown graphically for the average of each group in Fig. 6. The strongest group is Q and R, the commercial copper paints, where a tarry binder is

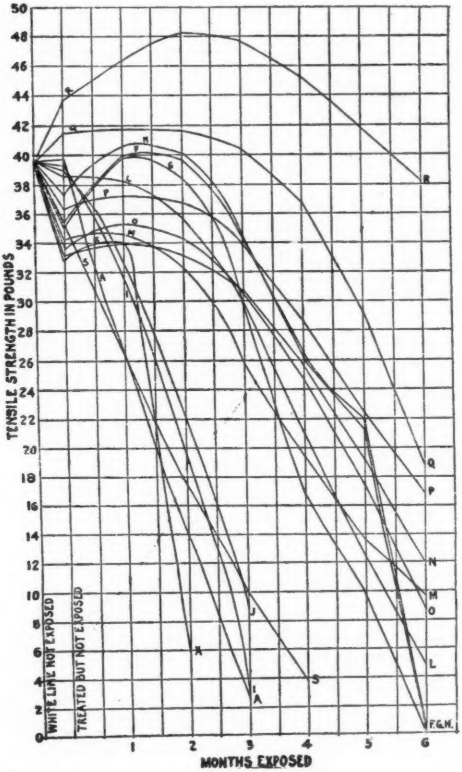

Fig. 5.—Tensile strength of cotton lines exposed to sea water at Beaufort, N. C.

combined with a toxic copper ingredient. The tars (F, G, H) show a rise and then a steady diminution in strength. The copper oleates, though showing the usual initial diminution of strength nevertheless hold up well during the period of exposure. The Dutch method (L) here again shows characteristics that make it difficult to combine with any of the groups. Bull's method, Petroleum Product Nos. 1 and 2, and Gilsonite, show no preservative action worth considering, as far as tensile strength is concerned.

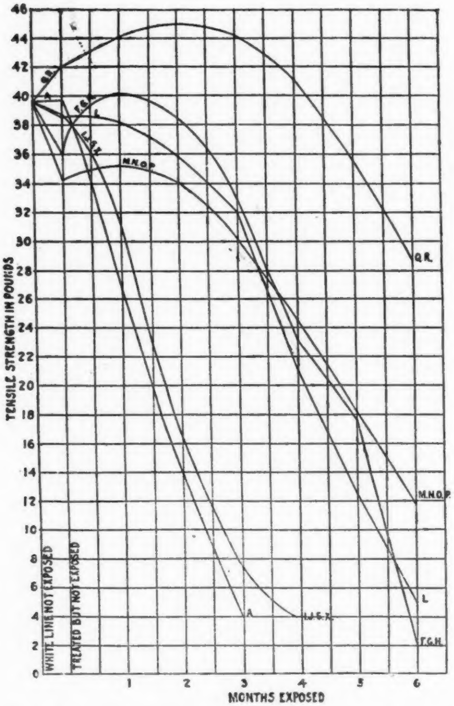

Fig. 6.—Tensile strength of cotton lines exposed to sea water at Beaufort, N. C. Grouped.

TABLE IV.—TENSILE STRENGTH IN POUNDS OF NO. 24 COTTON LINES PUT DOWN IN THE SEA AT BEAUFORT, N. C., FEBRUARY 15, 1922.

[One of each taken up each 30 days over a period of 6 months. Each figure is an average of 15 breaks except the untreated and unexposed control, which is an average of 60 breaks.]

Symbol	Treatment	Tensile strength, in pounds						
		Not exposed	Exposed, months					
			1	2	3	4	5	6
A	White line	39.3	33.0	5.3	2.9	x	x	x
F	Coal tar	35.4	46.0	44.9	36.2	23.2	18.0	
G	Pine tar	35.2	45.0	46.9	33.8	11.9	3.1	.....
H	Coal and pine tar, equal parts	37.4	45.0	46.8	33.9	27.9	16.2	.....
I	Bull's method	39.3	42.4	19.6	3.2	x	x	x
J	Petroleum Product, No. 1	39.0	40.0	23.4	8.7	x	x	x
M	Copper oleate 7.5%; 8 mg. copper per yard	34.2	36.2	36.6	28.6	16.6	11.0	.....
N	Copper oleate 7.5%; 12 mg. copper per yard; 5% oil; 1-1,000 cresol	33.2	35.2	33.8	33.9	25.4	20.8	.....
O	Copper oleate 12.5% solution; 18 mg. copper per yard	33.6	36.6	40.3	30.0	21.3	25.1	.....
P	Copper oleate 18 mg. copper per yard; 2% oil	36.3	37.2	39.0	37.0	29.7	19.5	.....
Q	Copper paint I; 50% creosote oil	41.5	42.0	42.4	40.8	41.0	33.0	.....
R	Copper paint II	41.7	48.0	50.0	49.5	47.0	40.0	.....
S	Gilsonite	35.5	28.2	14.5	8.5	3.9	x	x
X	Petroleum Product, No. 2	32.9	34.0	5.7	x	x	x	x
L	Dutch method	38.6	40.3	37.0	35.3	20.3	8.3	.....

x Indicates that the line is disintegrated.

DISCUSSION OF TENSILE STRENGTH IN THE LIGHT OF THE FOREGOING EXPERIMENTS.

Tensile strength is one of the most important properties of the lines used for fishing gear, and has been the only factor measured by other investigators. In considering the changes in tensile strength as influenced by preservation, it is necessary to consider (1) immediate increase or decrease of strength of line, caused by the physical properties of the preservative; (2) a later change in the tensile strength, caused by drying or other

change in the preservative; and (3) changes as influenced by the toxic or biological preserving properties of the preservative used. These will be considered separately.

1. *Immediate changes in tensile strength.* The fibers in a cotton line are short, but are made into a long line by being twisted together so that the friction of the fibers against one another causes the line to hold together as a continuous whole. When a line breaks, a force must be applied to the line which is sufficient to overcome the friction of the fibers against one another, or to break them; if the friction is greater than the tensile strength of the fibers, they will break; if the tensile strength is greater than the friction they will pull out. No doubt both things happen—some of the fibers are actually broken, while others are merely disengaged from the twisted strands. Now the introduction of a foreign material between these fibers and among the strands may greatly alter the properties and behavior of the line. If the foreign substance lubricates the fibers or otherwise diminishes friction, the line as a whole is weakened proportionately, so that when a pull is exerted on the line the fibers are drawn out or disengaged rather than broken. This weakening, we see, occurs in the case of many of the preservatives. In fact, the only preservative which did not cause an immediate weakening was copper paint. The waterproofing sample, being treated at the factory, was not measured immediately after treatment.

2. *A later change in tensile strength, caused by drying of the preservative.* In the case of those preservatives having a volatile and a non-volatile portion, the volatile, or soluble, portion evaporates or dissolves in time. The body, or non-volatile portion, then remains, and may markedly alter the strength of the line. Thus, the tars, while at first diminishing tensile strength by their lubricating effect, on drying out cause a marked increase of strength which may persist until the lines begin to deteriorate through decomposition. This is also true of the copper paints, waterproofing material, petroleum products, and slightly in some others, and is particularly noticeable in the case of those lines exposed to weather conditions in Washington.

It is necessary to take these facts into consideration in reading the graphs. The sudden initial drop in tensile strength may convey the idea that a preservative is poor, or a sudden ini-

tial rise that it is excellent. The differences are not, however, of great value in themselves. The important thing is to observe how much deterioration takes place on long exposure.

3. *The toxic or biological action of the preservative used.* If a line on treatment, drops in tensile strength from 40 to 35 pounds, and holds the 35 pounds six months, it is still in good condition; but if it increases at once in strength to 45 pounds and begins to lose its great strength in 60 days through the detrimental action of microorganisms, it may be totally worthless in 6 months. Furthermore, the increase in strength caused by heavy-body preservatives is always associated with a correspondingly great increase in stiffness and wiriness, as will be seen later. This marked loss does, in fact, occur in the tars, for after the volatile or soluble creosote is gone, the lines rapidly deteriorate. It is thus plainly to be seen that the principal detrimental agency is decomposition, and therefore the most important function of the preservative is to prevent this by means of a toxic ingredient that is insoluble in water and non-volatile in air.

It is at this point that criticism can be made of the English, Norwegian, and Dutch experiments, in which the experiments extended over only a short time, usually two months. Some of Bull's experiments covered eleven weeks. It will be seen from the graphs and figures presented herewith that the real differences do not come out very strikingly until three or four months of exposure, and six months are necessary to get a good test.

RESISTANCE TO MECHANICAL WEAR OR ABRASION.

It is impossible to say definitely what are the greatest enemies of lines. Breakage by pull against snags, and by the struggles of large fish, are important, of course; bacterial decomposition appears to be very important. Mechanical wear or abrasion caused by dragging the seines or lines over the gunwales of boats, or by the rubbing of the lines against each other in handling them, is no doubt also very important. Diminishing ability to withstand mechanical wear is, like tensile strength, an indicator of the general quality of the line, and if it can be rated quantitatively will give not only some measure of the general condition of any particular sample, but by imitating the wear that it is subjected to in actual use, will give a measure of this particular factor—ability to withstand abrasion.

It was therefore necessary to devise some means of measuring the amount of abrasion or rubbing a line can stand. A motor was arranged to draw samples back and forth over an edge, and to count the number of strokes required to wear the line in two. The great difficulty was in the nature of the edge. Woods of various kinds were tried, but the results obtained thereby were inconsistent because of lack of uniformity in the hardness of the edge. Steel, hard rubber, glass, etc., were tried, but none of these edges answered all the requirements of a satisfactory standard. Finally, the threads were drawn across one another, and the number of strokes necessary to wear out the sample was taken as a measure of this factor.

The construction and operation of the machine for making this test is shown diagramatically in Fig. 7. A is an eccentric, to which are fastened the lines to be tested, b and b^1, which are passed over the rollers, h and h^1, fastened at c and c^1. Other pieces of the same line, d and d^1, are made fast at e and e^1, and run through the slack part of b and b^1, at f and f^1. Weights of 1 kg. (g and g^1) are attached to the free ends of the lower piece of line. The eccentric A is revolved by a motor, imparting a reciprocating motion to the samples b and b^1, and causing them to saw across similar sample, d and d^1. The samples thus wear out and the weights drop to the floor; the number of strokes necessary to wear each sample down to a breaking strength of

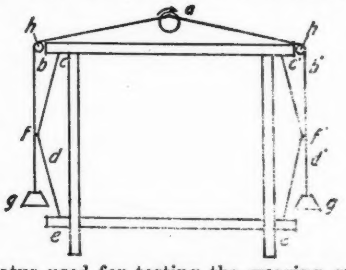

Fig. 7.—Apparatus used for testing the wearing quality of lines.

1 kg. is taken as a measure of the wearing quality. The machine was made so as to run 10 samples at a time, and a mechanical revolution counter was used to assist in keeping count.

Table V herewith gives the results of the mechanical wearing tests on the various samples exposed and tested.

TABLE V.—WEARING TESTS ON NO. 24 COTTON LINES EXPOSED AT BEAUFORT, N. C.

Symbol	Treatment	Number of strokes against itself necessary to wear out samples					
		Not exposed	Exposed, months				
			1	2	3	4	5
A	White line, untreated	264.7	56.8	x	x	x	x
F	Coal tar	189.4	172.4	95.4	103.9	34.4	14.9
G	Pine tar	159.7	141.4	97.8	75.1	57.4	x
H	Pine tar and coal tar equal parts	168.5	171.6	107.2	92.6	43.6	9.8
I	Bull's method	50.9	45.1	x	x	x	x
J	Petroleum Product, No. 1	281.3	124.2	x	x	x	x
L	Dutch method	46.6	84.6	79.4	91.0	88.4	1.3
M	Copper oleate, 8 mg. copper per yd. of line	118.4	167.4	141.2	129.2	12.8	8.1
N	Copper oleate, 12 mg. copper per yd. of line; oil 5%; cresol 1–1,000	127.5	157.3	117.0	150.9	79.4	42.8
O	Copper oleate, 18 mg. per yd. of line	191.1	191.9	143.6	123.3	40.4	48.1
P	Copper oleate, 18 mg. per yd. of line; 2% oil	141.7	228.8	157.4	182.4	122.0	13.0
Q	Copper paint I plus 50% creosote oil; 60 mg. copper per yd. length	23.0	57.4	43.6	58.7	56.7	34.2
R	Copper paint II, 270 mg. copper per yd. length	89.0	30.8	17.0	17.9	12.5	14.0
S	Gilsonite	280.0	207.4	24.4	x	x	x
X	Petroleum Product, No. 2	132.0	31.8	1.8	x	x	x

x Indicates that samples were disintegrated and gone.

DISCUSSION OF EXPERIMENTS ON WEARING QUALITY.

There is seen to be a wide variation in wearing quality. This quality of lines is influenced by the hardness or stiffness of the preservative. When it is dried out and wiry, the line wears out more rapidly than when it is soft and pliable. In the case of lines that have been exposed in the sea, there is an unavoidable deposit of sediment, sand, etc., among the fibers that probably increases abrasion in the test. Although the samples were washed before being tested, probably some of this sediment still remained. A sticky or adhesive preservative pulls out the fibers

rapidly and destroys the line quickly during the test. An oily or soapy preservative has the opposite effect of diminishing abrasion.

During the test, considerable heat is developed at the point of abrasion, which for one cause or another may vary and bring about disagreement in the results.

Overlooking the fluctuations caused by these things, we see that, in general, the results confirm and amplify conclusions already reached. Lines preserved with the following preservatives reach, before the conclusion of the period of exposure, such a state of disintegration that they will not stand any wear on

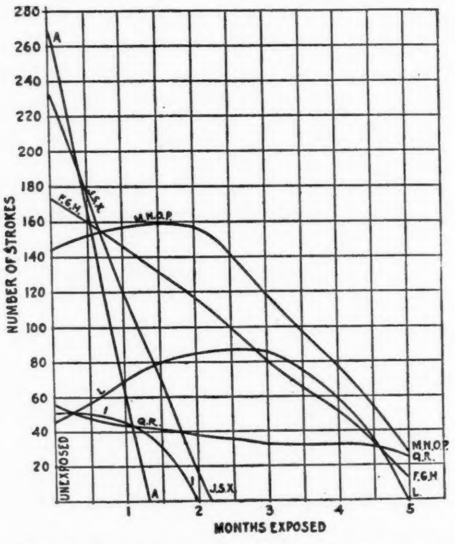

Fig. 8.—Wearing quality of lines exposed in sea water at Beaufort, N. C.

the machine: untreated lines, pine tar, Bull's method, Petroleum Products Nos. 1 and 2, and Gilsonite. Those which come out best in the end are the copper oleates, which take first and second places, followed by a copper paint. We may account for the superiority of copper oleate by (1) the fact that the fibers are effectively preserved against decay, and (2) the preservative itself is of a soapy consistency, which lubricates the fibers.

In Fig. 8 the results are grouped for similar preservatives where the wearing results are similar. It is there seen that ability to withstand wear of the kind effected by the wearing machine, is greatest at first in the white lines, (A) and all the preservatives reduce this ability. On exposure the white lines [and also Bull's method, the Petroleum Products and Gilsonite (A, I, J, S, X) which have an initial high wearing quality] rapidly lose the property by disintegration, so that in two or three months they are so far disintegrated as to fail to endure any test at all. The tars (F, G, H) and copper oleates (M, N, O, P) stand about the same at first in wearing quality, but on exposure the tars suffer a steady loss, while copper oleate preserves the wearing quality at a high figure longer than any other preservative studied. Its superiority in this respect is beyond question. The copper paints (Q, R) which show up so well in other respects are here at a decided disadvantage, as are also the tanning extracts, Bull's method, which is a failure, and the Dutch method, which shows fair, though by no means excellent, results.

It may further be remarked that this test is very severe, as will be noticed by the low figures for all preservatives for the fifth month. The poorer preservatives all fail very early. Any preservative which carries its line through six months exposure with a measurable wearing quality has some merit.

STIFFNESS.

Most preservatives alter the softness and pliability of lines, nets, seines, etc. If stiffness were not objectionable, much of our fishing gear might be made of wire. In many cases, stiffness is objectionable, and in some cases, such as that of gill nets, it is absolutely necessary that the lines be soft, pliable and small. Tar and other heavy body preservatives are useful for traps and the like, but because they bring about great stiffness, they are of limited usefulness. It is decidedly against a preservative to stiffen the lines to which it is applied.

To get a quantitative expression of stiffness, advantage was taken of the well known laws of the pendulum. The machine devised, constructed, tested, and used by the writers is shown diagrammatically in Fig. 9. The sample of line (a) is gripped between the wooden jaws (b). On the other end of the sample is attached a brass plummet (c) weighing exactly 50

grams. A scale is laid off on an arc below the pendulum thus formed, so that the circular distance from d to the point of rest of the pendulum is one-half a radian, (i.e., one-half the length of

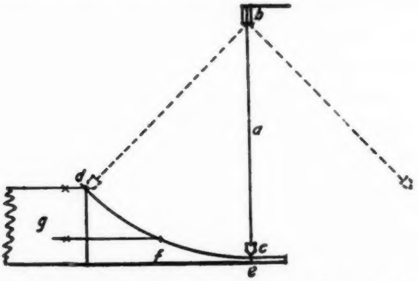

Fig. 9.—Apparatus used for testing stiffness of lines.

the pendulum). If the pendulum is displaced to d, and released, it swings through one radian, dg, and will continue to swing, but each oscillation is of lesser amplitude than the preceding, because of the friction in bending the line and, to a negligible extent, because of the friction of the air. When the amplitude has been reduced from one radian to one-half radian,

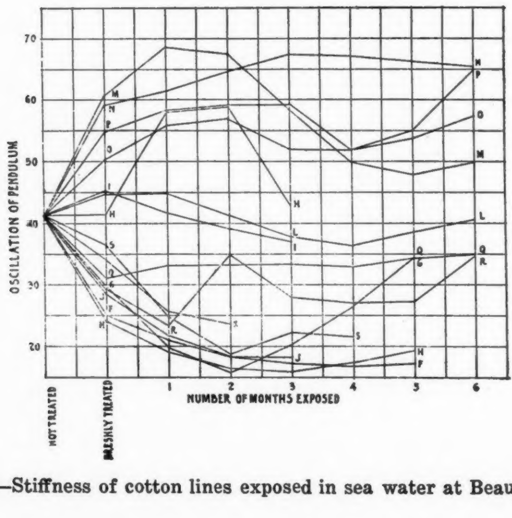

Fig. 10.—Stiffness of cotton lines exposed in sea water at Beaufort, N. C.

note is taken of the number of oscillations the pendulum has performed and this number is recorded as a measure of the stiffness.

The following table (VI) gives the number of oscillations required with the different samples (Beaufort series), which measures the stiffness of the lines. The more pliable the line, the higher the figure.

TABLE VI.—STIFFNESS OF LINES TREATED WITH THE SEVERAL PRESERVATIVES. LINES EXPOSED TO OCEAN WATER AT BEAUFORT, N. C.

Symbol	Method of treatment	Number of oscillations								
		Freshly treated	In Air First month			In Water Months				
			1 wk	2 wks	3 wks	1	2	3	4	5
F	Coal tar	25.0	19.7	17.2	15.9	19.3	18.9	16.6	16.1	18.0
G	Pine tar	29.9	19.9	17.6	17.5	15.0	14.8	18.1	27.4	34.2
H	Pine tar and coal tar mixed	24.2	18.0	16.7	16.3	18.0	14.8	16.6	16.5	19.2
I	Bull's method	45.1	40.7	43.7	43.7	44.8	35.9	37.0	x	x
J	Petroleum Product, No. 1	29.0	20.3	18.4	17.9	18.2	18.1	18.2	x	x
L	Dutch method	44.9	39.9	38.3	40.1	44.3	45.5	33.8	33.6	41.7
M	Copper oleate, 8 mg. copper per yard length	60.5	52.3	45.5	44.1	74.3	71.8	56.6	46.4	46.7
N	Copper oleate, 12 mg. copper per yard length, 5% oil 1-1,000 cresol	59.1	51.3	41.0	36.9	61.4	63.9	68.4	70.1	62.8
O	Copper oleate, 18 mg. copper per yard length	50.2	43.4	37.9	38.5	60.9	56.8	53.0	45.9	58.4
P	Copper oleate, 18 mg. copper per yard length, 2% oil	49.6	43.3	38.4	35.8	64.3	57.5	55.5	64.7	35.3
Q	Copper paint, No. 1	31.1	32.7	30.4	29.1	39.3	29.3	31.0	39.6	28.2
R	Copper paint, No. 2	29.4	31.3	28.7	26.1	14.6	26.4	33.9	23.6	23.3
S	Gilsonite	36.5	25.5	22.0	17.3	21.1	17.2	18.0	21.3	x
X	Petroleum Product, No. 2	34.3	29.2	27.0	22.3	18.7	23.5	x	x	x

x Indicates that line was disintegrated.

Figure 10 shows the result graphically for the individual lines. It will be noticed that, although each line shows fluctuations from month to month that may not have significance for our purpose, the lines naturally divide themselves into groups of

more and less flexibility. These groups, the copper lines (M, N, O, P), the tanning methods (I, L), the copper paints (Q, R), and those preservatives containing a heavy body, coal tar, pine tar, mixed tars, Petroleum Product Nos. 1 and 2, and Gilsonite (F, G, H, J, S, X), are grouped in Fig. 11. Here the lines preserved with copper oleate are far in the lead, showing upwards of 60 oscillations. Next comes those lines preserved by quercitron, Bull's method and the Dutch method (I, L), with around 40 swings; then the copper paints (O, R), with around 30 swings. Finally, the tars, Petroleum Products, and Gilsonite, with around 20 swings. If we express the flexibility of tarred lines as 1, then lines treated with copper paints have a flexibility of about 1½, tanned lines about 2, and those treated with copper oleate about 3.

DISCUSSION OF THE FLEXIBILITY TESTS.

It has been seen in the results of breaking and wearing tests that we have a choice of a number of excellent preservatives, while others are definitely eliminated from consideration by their failure to endure the tests. Those which fail to endure the breaking and wearing tests are waterproofing materials, Petroleum Products, Gilsonite, and Bull's method. Still in the running are the tars, copper paints, copper oleate, and the Dutch method. Where flexibility is an important consideration, there are now thrown out all the tars, the copper paints, leaving only the Dutch method and the copper oleate as answering the requirements of a first class preservative, which leaves the lines soft, with the copper oleate far ahead of the Dutch method. For gill nets, light seines and the like, copper oleate stands first in the tests so far considered.

Where stiffness is not objectionable, as in pound nets, traps, etc., the copper paints are indicated. No doubt copper oleate will answer splendidly also for this purpose, though the heavy concentrations of copper desirable for this purpose have not been tried. The copper paints have very much heavier concentrations of copper. Other considerations yet to be discussed bring out further differences.

SHRINKAGE OF COTTON LINES CAUSED BY THE APPLICATION OF PRESERVATIVES.

Some preservatives cause alteration of the length of lines; all that have been so far studied either do not affect the length

or else cause shrinkage; none have been encountered which cause increase of length. The changes in length have been ascertained for all preservatives studied by measuring the line before treatment under a constant pull of 2 kilograms, and after treatment, under the same conditions. Duplicate measurements are repeated to an accuracy of about 4 inches in 100 feet, that is, within .33 per cent. It was impracticable to make these measurements under constant temperature and humidity conditions, because of the large space required to stretch and measure the samples, and no room equipped for constant atmospheric conditions and of sufficient size was available. The following table VII, and Fig. 12, show, however, that the change is small, at greatest, so that errors caused by changing temperature and humidity would be negligible.

TABLE VII.—SHRINKAGE OF No. 24 COTTON LINES CAUSED BY THE APPLICATION OF VARIOUS PRESERVATIVES.

Symbol	Method of treatment	Per cent shrinkage
B	Copper oleate, 7%	.91
C	Copper oleate, 7%; 5% oil; 1–1,000 cresol	.98
D	Copper oleate, 11%	1.67
E	Copper oleate, 11%; 2% oil	1.14
F	Coal tar	2.48
G	Pine tar	2.51
H	Coal and pine tar, 50% each	2.00
I	Bull's method	3.48
J	Petroleum Product, No. 1	2.60
K	Waterproofing material	2.00
L	Dutch method	3.60
M	Copper oleate 7½%	....
N	Copper oleate 7½%; 5% oil; 1–1,000 cresol	.41
O	Copper oleate, 12½% strength	1.07
P	Copper oleate, 12½%; 2% oil	.99
Q	Copper paint I	.85
R	Copper paint II	.65
S	Gilsonite	2.87
X	Petroleum Product, No. 2	1.22

Noticeable shrinkage occurs only in the case of lines treated by hot aqueous bark extracts, Bull's method, and the Dutch method. But none of the methods causes enough shrinkage to make this an item of any practical importance. This factor should be considered, however, in connection with aqueous preservatives, especially those applied hot or repeatedly.

CHANGES IN WEIGHT CAUSED BY THE APPLICATION OF PRESERVATIVES.

All the preservatives studied increased the weight of the

lines, and obviously so because the preserving action depends on the deposit of a preservative material on the line, or among the fibers. This change is in some cases of serious importance, as

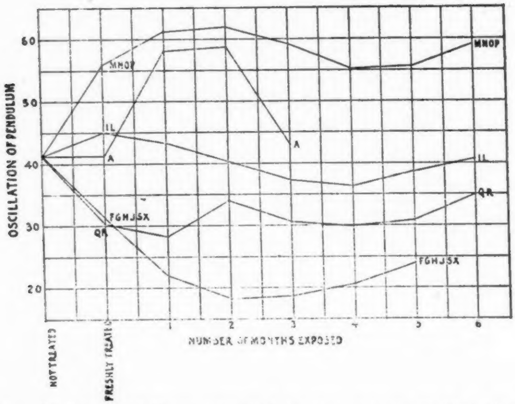

Fig. 11.—Stiffness of lines exposed in sea water at Beaufort, N. C. Grouped.

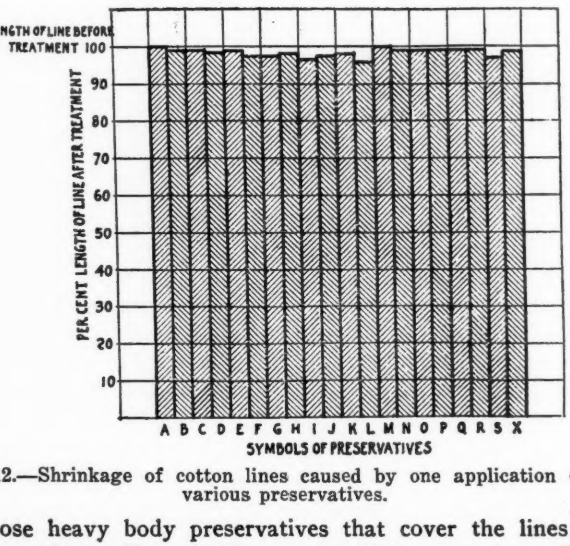

Fig. 12.—Shrinkage of cotton lines caused by one application of the various preservatives.

in those heavy body preservatives that cover the lines with thick coatings. The weighings were all done on the analytical

balance, and are accurate to the order of a milligram or two. By experimentation, it was found advisable to weigh in the air-dried or ordinary condition, which was the condition of lines in the ordinary air conditions of the laboratory. If the samples were dried to constant weight in an oven, they took up moisture so rapidly during the weighing that it proved impossible to weigh them without elaborate precautions. Where hundreds of samples were prepared, these precautions were out of the question. Table VIII gives the results of the determinations of weight, and Fig. 13 exhibits the results graphically.

TABLE VIII.—PERCENTAGE OF INCREASE IN WEIGHT OF LINES TREATED WITH VARIOUS PRESERVATIVES.

Symbol	Method of treatment	Percentage of increase in weight
B	Copper oleate, 7%	11.9
C	Copper oleate, 7%; 5% oil; 1–1,000 parts cresol.	18.0
D	Copper oleate, 11%	20.6
E	Copper oleate, 11%; 2% oil	22.9
F	Coal tar	68.5
G	Pine tar	53.9
H	Coal and pine tar, 50% each	48.0
I	Bull's method	9.8
J	Petroleum Product, No. 1	48.6
K	Waterproofing material	17.8
L	Dutch method	20.2
M	Copper oleate, 7½%	10.2
N	Copper oleate, 7½%; 5% oil; 1–1,000 cresol	15.1
O	Copper oleate, 12½%	15.4
P	Copper oleate, 12½%; 2% oil	18.6
Q	Copper paint I	65.5
R	Copper paint II	127.0
S	Gilsonite	46.0
X	Petroleum Product, No. 2	35.3

It will be seen that the preservatives which add least to the weight are copper oleate and tanning methods, Bull's and the Dutch methods. Tars add about 57 per cent to the weight of the line and copper paint doubles it.

The weight of the preservative is important in two ways: (1) added weight increases the labor of handling and the strains imposed on the line, and (2) added weight is an important consideration where lines, nets, etc., are bought by weight, already treated or preserved.

(1) In such gear as large menhaden purse seines, where the seine must be handled by hand by crews in the "purse boats,"

the added weight of the large seines must be moved by a larger force than would otherwise be required. It is also important to work as rapidly as possible when a school of fish is at hand, and the added weight of a heavily-tarred seine can not fail to reduce the speed of operations, and increase the danger of losing the school.

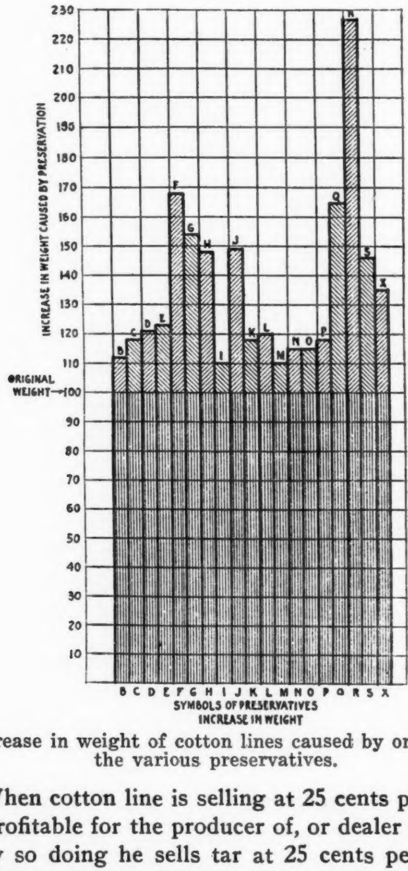

Fig. 13.—Increase in weight of cotton lines caused by one application of the various preservatives.

(2) When cotton line is selling at 25 cents per pound, it is obviously profitable for the producer of, or dealer in, lines to tar the line; by so doing he sells tar at 25 cents per pound. It is correspondingly unprofitable for the fisherman to buy line without a consideration of the added weight of the tar. This is an important item of cost where netting is used in large quantities.

Copper oleate being by far the lighter of the more effective preservatives, has a great advantage over tar, and deserves further study and consideration as a preservative for large heavy seines where tar is now used.

RESISTANCE AGAINST FOULING BY BARNACLES, HYDROIDS, ETC.

It has already been shown that in those circumstances where stiffness and weight of lines was not a very important factor, numerous preservatives were available to prolong their strength and wearing qualities. It is only in the case of traps, pound nets, and stationary gear of various kinds that stiffness and weight are of minor consideration. But since the nets remain in the water for long periods, another important factor arises, namely, fouling by barnacles, hydroids, and other attached organisms. The disadvantages brought about by the growths are numerous. (1) They greatly increase the weight of the nets, thus increasing the labor and time required to fish them; (2) the extra weight (which may greatly exceed the original weight of the net) puts an added strain on the net; (3) the accumulation of growths on the net increase the collection of floating debris from the water, thus further straining the nets; (4) the net offers greater resistance to stream and tide flow when fouled, and is consequently put under greater strain; (5) these growths, especially barnacles, injure the fishermen's hands.

Tarred lines, though fairly well preserved in strength, yield readily to fouling with barnacles and hydroids; so do lines treated by Petroleum Products Nos. 1 and 2, Bull's method, and Gilsonite. Those lines treated with preservatives which contain copper, even in small amounts, resist fouling. Lines treated by the Dutch method fouled somewhat in four months at Beaufort. Those tested with copper paint, and all those treated with either of the copper oleates, were, after the fourth month in the sea water at Beaufort, entirely free from all attached growths visible to the eye. The tiny amount of copper which remained in the lines (2 to 4 mg. per yard, as shown by a determination of the copper present) shows the effectiveness of copper in preventing fouling. Of course, copper oleate can and should be applied in much heavier concentration on lines to be exposed continuously in the water. The advantages brought about by this single point of superiority would, even if there were no others, alone justify the use of copper in lines for continued submersion.

The following tabular record gives a statement of the external condition of the lines after the fourth month at Beaufort:

TABLE IX.—CONDITION OF LINES AFTER FOURTH MONTH TESTED FOR FOULING.

Symbol	Treatment	Condition
A	White line; no treatment.	Disintegrated and gone.
F	Coal tar................	Fouled with hydroids and barnacles.
G	Pine tar................	Do.
H	Pine and coal tar........	Do.
I	Bull's method...........	Covered with dense matting of hydroids.
J	Petroleum product, No. 1.	Do.
L	Dutch method..........	Few hydroids; nearly clean.
M, N, O, P	All copper oleate........	Substantially clean; very few barnacles; no hydroids.
Q, R	Copper paints...........	Perfectly clean; no growths.
S	Gilsonite...............	Fouled with hydroids and barnacles.
X	Petroleum Product, No. 2	Fouled, less than Petroleum Product, No. 1. (This sample had been in water only 1 month.)

The conclusion to be reached in this section is that copper oleate and copper paint are the only preservatives among those tried that prevent growth of attaching organisms on the line. The Dutch method reduces, but does not prevent such growths.

LABOR AND TIME REQUIRED FOR APPLYING PRESERVATIVES.

Some preservatives that might answer well some of the requirements of a good material, are out of the question because of the labor and time required to apply them. The laboriousness of the application of tar, the time it takes to dry, and the fact that it is a black, sticky nuisance, have caused many a net to go unpreserved. When labor and time are expressed in terms of expense, it will be found expensive, also. In this way cheap preservatives may in the end turn out to be the most expensive.

TABLE X.—TIME REQUIRED FOR APPLICATION AND DRYING OF PRESERVATIVES.

Preservative	Number of applications and time required for each to dry	Total time required for drying
Copper oleate	One application.	30 to 45 minutes.
Pine tar 50% in benzol	One application.	10 to 12 hours.
Coal tar and pine tar, 50% benzol	One application.	20 to 24 hours.
Coal tar 50% benzol	One application.	24 hours.
Quercitron:		
Bull's method } Dutch method }	Three applications. 4 to 6 hours each.	12 to 18 hours.
Gilsonite	One application.	24 hours.
Petroleum products, Nos. 1 and 2	One application.	36 to 48 hours.
Copper paint I	One application.	36 hours.
Copper paint II	One application.	48 hours.

This record of the time required to apply the various preservatives studied in this investigation shows copper oleate to be far in the lead. By any other method the lines or nets would require to be taken out of service at least a day for treatment, not including the time necessary for drying the net before the treatment is applied.

In the case of copper oleate, lines or gear could be taken up, dried and returned to use the same day, except in case of such gear as pound nets, where the labor of taking up and setting is excessive. In the case of gill nets, a very light application can be applied frequently; by so doing, little time is required, and stiffness and weight are kept at a minimum, but sufficient copper can be kept in the line to effect excellent preservation.

Copper paints, excellent preservatives though they are in many other respects, are again at a disadvantage.

The quercitron preservatives (and tanning methods in general) are for practical purposes eliminated by the excessive time and trouble required for their application.

COLOR IMPARTED TO LINES BY THE PRESERVATIVES.

All the preservatives studied change the color of the lines. Just what the value of color in a line is, and what color and shade would be preferable, we do not know. There is a large literature on the subject of color vision in fishes, but results by different observers are quite inconsistent. Still less do we know of the reactions of fish to colors which they may distinguish. However, since many people who are interested in net preserva-

tives have their own, and very often decided, opinions on the subject, the colors produced are given here:

TABLE XI.—COLOR IMPARTED TO LINES BY PRESERVATIVES.

Preservative	Color of treated line
Copper oleate	Apple green, sky blue, or strong brilliant green, depending on concentration of preservative.
Tar	Dark brown or black.
Copper paint	Dark coppery red.
Petroleum Products, Nos. 1 and 2	Black.
Gilsonite	Black.
Tanning extracts:	
Dutch method	Brown.
Bull's method	Dark brown.

GENERAL DISCUSSION AND SUMMARY.

There have been presented the results of investigations which establish certain facts regarding the characteristics of several important or well known net preservatives. These results show that some materials that are used have little or no value as preservatives, others are good in some respects, while still others excel in most or all respects.

The following materials for, or methods of, preserving may be eliminated, on the basis of these results: quercitron mordanted with potassium bichromate (Bull's method), waterproofing material, Gilsonite, and the Petroleum Products Nos. 1 and 2.

We may classify the points of usefulness of the remaining preservatives on the basis of the service the treated gear must perform:

(1) Where the gear is to remain immersed for a long time, and where added weight and greatly increased stiffness are permissible, the copper paints excel. They protect tensile strength, and prevent fouling, but they resist mechanical abrasion rather poorly. The tars are good preservatives, but foul heavily with hydroids and barnacles. Both are slow in drying.

(2) Where softness, flexibility and lightness are necessary, as in gill nets, light seines, etc., the choice is between copper oleate and the Dutch method with copper oleate leading in every particular—preserving quality, wearing quality, flexibility, light weight, insignificant shrinkage, and particularly ease and rapidity of application.

Copper Oleate. There are many reasons for believing that copper oleate will answer as well for the heavy duty set nets, traps, etc., as for the lighter gear, the difference being in the concentrations of copper oleate to be used. In the case of gill nets, a 10 to 12 per cent solution in gasoline, benzol, or carbon tetrachloride with the addition of a little ordinary lubricating automobile oil may be applied frequently; the heavy gear may be treated with much more concentrated solutions, and not so often.

So far as the writers are aware, copper oleate has never been used before as a net preservative unless we may regard as the same the soap-and-bluestone-treatment said to have been used by the French sardine fishermen. At least it has never been used in the way here recommended. Cunningham * mentioned the process as used by the French, and in his trials included lines treated with soap and bluestone, but his results were not at all encouraging. On the basis of our work, a solution of copper oleate, taking all factors into consideration seems best and most promising of all and capable of being used to a great annual saving by the fishing industry, and the writers submit this as the principal constructive part of their work.

Copper oleate can be had in the market as a commercial article at about 22 cents per pound in barrel lots, containing up to about 15 per cent copper. The two commercial samples obtained and examined in this work did not appear entirely satisfactory. They contain a high percentage of substances insoluble in gasoline, benzol, etc., which appear to be by-product salts that have not been removed.

Accordingly, some work has been undertaken looking toward the best methods of commercial manufacture of copper oleate. Four principal methods are being studied, namely, (1) precipitation of sodium oleate with copper sulphate, washing and drying; (2) direct action of oleic acid on cupric oxide—the ordinary black copper oxide; (3) the direct action of oleic acid on copper acetate, wherein at 120° to 140° C. the acetic acid is driven off; and (4) direct solution at about 120° C. of copper carbonate in oleic acid, or commercial red oil, whereby carbon dioxide and water are driven off. At the present writing the last named method seems most practicable and economical, and

* Cunningham, J. T., The Chemistry of net-curing, Fish Trades Gazette and Poultry, Game, and Rabbit Trades Chronicle. Vol. XX, Nos. 993 to 1009, inclusive, June-September, 1902. London.

produces an excellent product. This part of the work is being continued and is subject to a later report.

Oleic acid, and also copper oleate, are readily oxidizable. Heating of nets piled up closely is well known to be caused by oxidation of reducing substances in or on the nets. If oleic acid or unoxidized copper oleate is present in large quantities, it is possible that the nets might heat. For this reason, the process of manufacture should include "blowing" the melted copper oleate with air until it becomes saturated with oxygen before packing.

The general summary of the work is presented herewith in tabular form:

TABLE XII. SUMMARY OF PROPERTIES OF NET PRESERVATIVES

Preservative	Tensile strength	Wearing quality	Flexibility	Shrinkage
Copper oleate without binder	Causes immediate diminution by lubrication of fibers. Thereafter tensile strength remains constant over long period. Excellent preservative.	Preserves wearing qualities over long periods in salt water, but not in fresh water.	Flexibility considerably increased immediately after treating. This flexibility decreases after two or three weeks to an equality with untreated line. Twine remains soft and pliable. Suitable for gill nets.	Shrinkage very small Causes about .5 to 1.5% decrease in length after one application.
Tar (pine, coal and mixed).	Immediate diminution of tensile strength followed by marked increase, which drops off after two months in salt water.	Very good on freshly treated lines but diminishes rapidly on being exposed. Exposed lines not so good as copper oleate.	Very stiff. Fewer oscillations of pendulum than any other preservative.	Shrinkage not great, but a little more than copper oleate. Averaged 2.22% on one application.
Copper paint Nos. 1 and 2.	Slight immediate increase followed by marked increase, which remains quite constant even after long exposure. Good preservative.	Poor resistance to mechanical wear.	Causes immediate stiffening but not to as great a degree as tar. Copper paint No. 1 remains fairly constant while copper paint No. 2 continues to grow stiffer.	Very little shrinkage. About .5% on one application.
Petroleum Product Nos. 1 and 2.	Very little immediate change. Product No. 1 shows marked increase after a short time. Product No. 2 shows little change. Both decrease very rapidly on being exposed. Poor preservative.	Product No. 1 when freshly applied resists mechanical wear better than any other preservative. Product No. 2 resists wear only moderately well. About ½ as well as No. 1. On exposure both rapidly lose resistance to wear.	Causes considerable stiffening which increases for three or four weeks and then remains constant.	Shrinkage about 2% on one application.
Gilsonite.	Slight immediate decrease followed by rapid decrease during time of exposure. Poor preservative.	Resistance to mechanical wear very good when freshly treated but this quality soon disappears when the line is exposed.	Causes a little immediate stiffening and grows gradually stiffer for about 4 weeks. About like tar.	Shrinkage about 2% on one application.
Tanning extract (quercitron with potassium bichromate as a mordant.) (Copper omitted)	No immediate change in tensile strength. Little change noticed on Key West and air conditions lines but strength decreased rapidly on Beaufort lines. Poor preservative, as used.	Very poor.	Flexibility of line little affected.	Considerable shrinkage as compared to most other treatments this line showing 3.48% decrease in length on one application.
Tanning extract (quercitron with potassium bichromate as a mordant.) (Copper omitted).	Practically no immediate change. Experimental lines at all places endured six months with some tensile strength remaining. Good preservative, especially for cotton lines.	Poor.	Flexibility of line very little affected.	Shrinkage comparatively large, as with most preservatives applied hot. Decrease in length 3.6% on one application.

TABLE XII. SUMMARY OF PROPERTIES OF NET PRESERVATIVES.—Cont.

Preservative	Increase in weight	Fouling	Time required for application	Color
Copper oleate without binder.	Increase in weight not great. Average of all lines treated shows about 16.5% gain in weight, as applied.	Very little fouling. A few barnacles were in evidence but no hydroids or other growth appeared on four months' exposure.	Lines or nets can be treated in short time. Should be immersed for 5 or 10 minutes and will dry in about ½ hour.	Color varies from a light green to a darker bluish green depending upon concentration of the preservative.
Tar (pine, coal and mixed).	Increase in weight very high especially in case of coal tar. Average increase 56.8% when applied from 50% benzol solution.	Lines contained heavy growth of hydroids and barnacles.	Much labor and time required to treat line. From 24 to 36 hours required for drying.	Dark brown or black.
Copper paint Nos. 1 and 2.	Greatest increase in weight of all preservatives studied. Copper paint No. 1—65%. Copper paint No. 2—127%.	No fouling of any sort after six months exposure.	Not much labor or time required. Drying before use unnecessary.	Dark red.
Petroleum Product Nos. 1 and 2.	Increase in weight averages about 41.9%.	Lines contained heavy growth of hydroids and barnacles. Preservative seems to have no anti-fouling quality.	24 to 36 hours required for drying.	Black.
Gilsonite.	Increase in weight 46.0%.	Lines exposed for short time are laden with heavy growth of hydroids and barnacles.	Requires but little time to apply but is rather slow drying. About 24 hours required.	Black.
Tanning extract (quercitron with potassium mate as a mordant.) (Copper omitted.)	Very little increase in weight. About 10%.	Lines carried heavy growth of hydroids and barnacles.	Two treatments with the extract and one treatment with the mordant. About 24 hours required for entire process, including time of drying.	Brown.
Tanning extract (quercitron with potassium bichromate as a mordant.) (Copper omitted.)	Increase in weight 20%.	Not much fouling after five months' exposure in sea water at Beaufort, N. C.	Time required same as that of tanning extract listed above.	Dark brown.

Discussion.

MR. TAYLOR: I think it is safe to say that all the fish taken commercially in the United States—for that matter, in the world—are taken by means of nets or lines made of some kind of textile thread; usually cotton, sometimes linen, hemp, or even silk. But these are all perishable, and naturally some means of preservation is most important. The statistics we have indicate that the value of the gear in the United States made of cotton, linen, hemp, and so forth, is about $15,000,000. How long it takes to turn this over we do not know definitely; presumably somewhere between one year and two years is sufficient to demand an entirely new outfit. The cost, then, will range somewhere less than $15,000,000 a year for nets,

lines, traps, etc., made of twine. If we could double the life of that material we would save something like ten or fifteen million dollars a year. The work we have done indicates that we can go a long way toward at least increasing the life of these lines, if not actually doubling it. In some cases we have very much more than doubled the life of the lines as compared with untreated white lines remaining permanently in ocean waters until they were completely rotten.

MR. J. N. COBB, Seatle, Wash.: Have the preparations you tested been used before?

MR. TAYLOR: All but copper oleate, which we made.

MR. J. N. COBB: Is it the one that proved best?

MR. TAYLOR: Yes. The idea occurred from the use of bluestone and soap dissolved in water. Of course, copper oleate is one of the things supplied by that reaction. We found that copper oleate was the only one soluble, so we ignored everything else and took the copper oleate dissolved in gasoline.

MR. J. N. COBB: You stated that a gill net could be used practically one year in the salmon industry. My experience in Alaska gill netting for salmon is that we would start with an old net and use it about two weeks; then we would bring it in and dry it, putting out a new one. That new net finished the season, then we would use it again for the first few weeks of the next season. That would mean that we used a gill net three months or less, and that was the life of it.

MR. TAYLOR: I will have to add here, Professor Cobb—for the sake of brevity I had to leave out a good many things—that we have been carrying on two more series of experiments in addition to the ones mentioned in the paper: one at Woods Hole, Massachusetts, and the other at Put-in Bay, on Lake Erie. We found that fresh water is very much harder on the lines than salt water. Our copper oleates are not showing up nearly as well in Lake Erie as they have been at Beaufort and Key West. Copper oleate appears to be more soluble in fresh water than in salt water.

MR. J. W. TITCOMB, Hartford, Conn.: Can a commercial fisherman who wants to buy a net or treat a net tell from your paper what these different preparations are which you compare?

MR. TAYLOR: In most of them there would not be any difficulty. One or two have been withdrawn from the market; in the other cases the advertising matter makes known what is in it. If a fisherman reads between the lines and reads the circulars, he can very easily tell.

MR. TITCOMB: This copper oleate is a preparation which you have yourself devised?

MR. TAYLOR: Yes. We are now making it up and beginning to treat lines for people experimentally. We are sending to the laboratory at Beaufort a case of this stuff put up in tin cans, with instructions to give it free of charge to any of the fishermen who want to try it. We furnish it for a limited time.

MR. TITCOMB: After you have furnished it free for a time, what do you propose to do? Are you going to commercialize it, or is it going to be given out so that anybody can make it?

MR. TAYLOR: Anybody can use it who wants it; it is perfectly free.

MR. TITCOMB: It is merely a matter of giving the formula?

MR. TAYLOR: Yes. We are making it now ourselves in order to encourage the trial of it. Of course, we do not expect to continue that; it is merely for experimental purposes. We give it to people who show a willingness to try it out and to keep us informed of the results.

MR. J. N. COBB: Have you worked out any estimate of the cost of this material as compared with the others?

MR. TAYLOR: The cost depends to a considerable extent on the solvent. There are several substitutes for gasoline at our disposal; kerosene can be used, but it takes longer to dry and leaves the line more oily. Carbon tetrachloride would be ideal, because it is non-inflammable, but it costs four times as much as gasoline. Anybody can use carbon tetrachloride who wants to, but I do not think many people will want to pay $1.30 a gallon for it.

MR. J. N. COBB: You say copper oleate is not inflammable?

MR. TAYLOR: No; but when you dissolve it in gasoline of course it is highly inflammable until the nets dry out.

MR. J. N. COBB: That, of course, is the principal trouble with the tar preparations; there is apt to be spontaneous combustion at any time if you get the sun shining on it in a room. We have had that several times.

MR. A. L. MILLETT, Boston, Mass.: What is the ratio or proportion of increased life by this method as against increased cost?

MR. TAYLOR: So much depends on the nature of the service the line is expected to perform. All our experiments have been in connection with continuous exposure under the water, allowing the lines to rot. That does not happen in actual service; it goes in and out.

MR. MILLETT: You claim that lines treated by this method last twice as long, do you not? Naturally the life would be twice as long in any event.

MR. TAYLOR: I think that is about the right estimate. It is a question of labor more than anything else.

MR. MILLETT: Would the longer life actually mean a lower cost?

MR. TAYLOR: I have not exact figures on that, but I can give you a guess unhesitatingly that it would.

MR. MILLETT: You said that in your test it took those that were painted with the ordinary copper paint, such as is used on a ship's bottom, forty-eight hours to dry. Why did it take so long, when it will dry on a brush?

MR. TAYLOR: The copper paint used in net preserving is not the same. It has the same active ingredients, but the binder is different. We know it takes forty-eight hours to dry; it is recommended, however, that the painted line be put immediately in water without drying.

MR. C. F. CULLER, Homer, Minn.: What is the temperature of the water in which you make these experiments?

MR. TAYLOR: The water at Key West is about 80. At Beaufort, about the middle of February, as I recall, the water was about 45 or 50; in August, about 80.

MR. CULLER: We use a number of seines, and the temperature of the water in summer time ranges as high as 96 to 100. Do you know whether

or not the copper oleate would act as a preservative in that case?

MR. TAYLOR: My advice would be not to try copper oleate in fresh water until we have made more experiments. We feel quite positive about the results in salt water, but our experiments in fresh water are not turning out so well.

MR. MILLETT: Have you made any experiments in waters at Cape Cod or along the Nova Scotia or Labrador coasts?

MR. TAYLOR: We have a series now going on at Woods Hole.

MR. MILLETT: Would it make any difference, do you think, as to the temperature of the water up there?

MR. TAYLOR: So far the Woods Hole series have been running like the Key West series—not much difference.

OCTOMITUS SALMONIS, A NEW SPECIES OF INTESTINAL PARASITE IN TROUT.

By Emmeline Moore
New York State Conservation Commission, Albany, N. Y.

Author's Note: The preliminary paper under the caption, "Giardiasis of Trout,*" was read at the meeting of the American Fisheries Society, Madison, Wis., September 7, 1922. Since that date further study of the organism in question requires a correction in nomenclature, necessitating a shift in generic position from the genus, *Giardia,* to the genus, *Octomitus.* The specific name, *salmonis,* is retained under the new designation. Revision of the text has been made in accordance with the later findings.

INTRODUCTION.

Octomitus salmonis Moore is a flagellate parasite occurring in the intestine of trout. It is widely prevalent in trout-rearing hatcheries, affecting various species in the fingerling stages. The presence of the organism in large numbers produces serious disturbances of the intestinal tract attended by evident symptoms of dysentery. The disease may cause serious epidemics accompanied by high mortality.

Without doubt the disease octomitiasis caused by *Octomitus salmonis* is a very common cause of hatchery troubles. The papers and discussions on fish pathology appearing in recent numbers of the Transactions of the American Fisheries Society have indicated the widespread nature of certain hatchery diseases, variously designated as "gill trouble" by local hatchery men, or as "whirling sickness" by Hayford (1921) and Foster (1921). There is evidence, also, of a close similarity between the symptoms produced by *Bacterium truttae,* as described by March (1901, 1902) and those of fish afflicted with *Octomitus.* It seems quite probable that we are dealing with the same disease, whose various manifestations have been studied from different points of view, and that the inciting cause is not a bacterium, but the protozoan parasite, *Octomitus salmonis.*

The recurrence this year of an epidemic of "gill trouble" or "whirling sickness" among brook trout fingerlings at the State

*** Awarded the prize for the best contribution on biological investigations applied to fish-cultural problems.**

hatchery at Bath, N. Y., led the Conservation Commission to inquire into its cause. It had been assumed, because of the apparent symptoms of "gill trouble," that the water was low in oxygen. Accordingly, about five years ago, a fountain and flume were introduced into the system of water supply to improve the aeration. There appeared to be temporary relief, yet the losses continued annually to be heavy. The mortality was especially high last season and on the reappearance of the epidemic in April of this year the whole problem at the hatchery was given intensive study.

Preliminary to the study of the disease a sanitary inspection of the plant and a chemical analysis of the water, including oxygen determinations, were made by experts in these fields in the Commission. Their results, which are appended to this paper, show that the sanitary conditions of the plant are excellent, but a low oxygen content prevails in the water supply, the gaseous oxygen present in water delivered to the hatchery troughs being only 2.10 parts per million, or 18.5 per cent saturation at 9 degrees Centigrade.

While it is reasonable to suppose that the annual heavy mortality of fingerlings at the Bath hatchery may be corrrelated with a possible low resistance of the fish due to a deficiency in the oxygen supply, it must be noted that, after the epidemic ceases, the fingerlings, which either escape the infection or acquire immunity, thrive remarkably well. Moreover, at other hatcheries, where the oxygen relations are notably good, the disease has been observed to approach the nature of an epidemic. That the fatalities were not more serious at the various hatcheries may be attributed to delayed infection or to the presence of other factors and varying practices at the different hatcheries.

That the disease should be locally diagnosed as "gill trouble" was not unnatural under the circumstances. The swollen exposed gills of the sick fish and the apparent effort in breathing seemed to indicate this as a primary cause of death, particularly since it was known that the oxygen supply approached the critical point for fishes. Persistent and careful study revealed no definite lesions of the gills, excepting that they were somewhat swollen and usually clogged with debris. It was observed, however, that troughs and races carrying approximately the same numbers of fingerlings showed vast differences in mortality

and, where the numbers of sick fish were large, the appearance of the excrement suggested that the seat of the trouble was in the intestines rather than in the gills. This proved to be the correct clue. On further search it was found that the fish in the entire hatchery were quite generally infected with the intestinal protozoan, *Octomitus*. The sick and dying fish were so heavily parasitized as to leave no room for doubt that *Octomitus* was the chief cause of the trouble. Further observations, therefore, were directed toward the study of this organism and its effect upon the fish in producing the disease.

SYMPTOMS OF THE DISEASE AND DIAGNOSIS.

So far as observed there are no definite external lesions, though badly infected fingerlings show somewhat abnormal coloring and a characteristic behavior. The dwarfed emaciated specimens often appear blackish, while those of an older growth present a pale or faded appearance. Balance seems easily lost and the fish turn over repeatedly with a "whirling" or "corkscrew" motion. Weakened by the disease they are unable to stem the current of the water which wafts them toward the foot of the troughs where they congregate in the corners, nose along the sides and near the surface and eventually die on the screens. As the sick fish turn over on their backs the gills are in feverish action and appear distended, a symptom which has doubtless given rise falsely to the diagnosis "gill trouble."

The examination of the intestine gives the more dependable diagnosis, the walls of which in bad cases of infection appear translucent, yellowish or whitish and somewhat inflated. The contents are watery and easily run away from the vent. In the earlier stages of infection the motile organisms are most abundant in the fore-intestine, but later they are more generally distributed in the lower intestine and the rectal region. In severe cases of infection among the young fingerlings the entire lumen of the fore-intestine, then devoid of food contents, may be filled with a mucous fluid in which the motile parasites are exceedingly numerous. By transferring a drop of this fluid to a microscope slide for examination they may be observed, even with medium powers, as minute, watery, pear-shaped objects, extremely active, moving forward through the fluid with a revolving or cyclic motion.

Lesions are produced in the walls of the intestine and in the glandular tissue of the caeca,* which provide sufficient explanation for the cause of death. These lesions are occasioned by the activities of the parasite in passing through the various stages of its life history. They will be considered in detail later in the paper.

SUSCEPTIBILITY AND MORTALITY.

All species of trout fingerlings thus far examined are susceptible to the disease—brook, brown, rainbow, steelhead and lake trout—approximately in the order named. The susceptibility of brook trout over other species is pronounced and may help to explain the decline in brook trout production at certain well known and long established hatcheries.

Mortality is highest among the smaller fingerlings. During the single epidemic which has been observed, the larger number of deaths occurred among fingerlings of 1⅛ inches to 1¾ inches in length. Infection begins soon after artificial feeding commences and progresses rapidly for about 6 to 8 weeks, when a decline sets in. These periods would probably vary with local conditions. There may be recurring waves of the disease during the season with relatively less mortality among the larger fingerlings. It may be that in cases of epidemics all contract the disease and that those affected lightly develop immunity. It is certain, from the large numbers examined throughout the season, that most of the fingerlings which survive are to a large extent carriers. Even adult trout about the hatcheries have been found to be carriers, though apparently unaffected by the presence of the organism.

The gradient of mortality, showing the approximate number a trough can carry without loss from the disease, could not be completely established this season, but it was found that in troughs under special observation carrying 500, 300 and 100 fingerlings, 2½ to 3 inches in length, there were no losses after the second day following removal from troughs in which the disease was rampant.

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* Dr. H. S. Davis, Pathologist of the U. S. Bureau of Fisheries, investigating simultaneously the cause of an epidemic among fingerling rainbow trout at White Sulphur Springs, W. Va., ascribes, in his unpublished researches, the cause of the disease to the organism in question and finds evidence of an invasion of the glandular tissue of the intestinal and caecal epithelium.

High mortality is a relative term. To many a practical fish culturist the loss of 25 per cent of the fingerlings has come to be regarded as the normal loss to be expected. On the face of it that loss seems abnormally high. Fingerlings have been dropping away season after season without apparent external signs of disease or without knowledge of the reason why. It seems more than likely that the annual loss in the hatcheries, that is, "the normal loss to be expected," disregarding the loss from epidemics, is referable in a high degree to individual cases of octomitiasis.

DISTRIBUTION.

Octomitiasis appears to be a disease of domestication. Although the organism which produces it has only recently become known it is not necessarily a new disease. Infection by *Octomitus* has been found in all of our trout-rearing hatcheries in the State and in three private hatcheries which have come under inspection. It is probably endemic in most of them in this country. Under conditions of artificial feeding and crowding in the hatchery the disease appears to be aggravated, although there is wide variation in the different hatcheries as to the extent of the trouble. The survey of the field for the presence of *Octomitus* in wild trout has been begun, but with insufficient observation thus far to warrant a generalization regarding its distribution in the wild state.

TRANSMISSION.

The transmission of the organism to fish in the hatchery may be considered from several standpoints. In its adult, active, motile form *Octomitus* does not persist long outside the intestinal tract, but forms cysts by rounding up and developing about it a resistant wall which survives desiccation for considerable periods. The ordinary motile form, if taken into the intestine of the fish, would hardly survive the digestive juices of the stomach, while the cyst with its resistant wall could reach the seat of infection in the fore-intestine. If such is the case, bits of excrement from infected fish easily explain its transfer from fish to fish.

If it is found that wild fish are carriers of the organism, the original "seeding down" of a hatchery can be explained from this source. Persistence of the disease in the hatcheries is

readily explained by the neighborly way we have of exchanging eggs and fish, by keeping adult brood fish which are carriers, and by permitting infected fish in the source of the hatchery water supply.

It has been thought that a probable source of the organism, *Octomitus*, in the hatchery might be derived from the frog which harbors a somewhat similar intestinal parasite. *Hexamitus intestinalis* Dujardin (13) and comparative studies on local material were made to elucidate this point. Two species of frogs, the pickerel-frog (*Rana palustric* Le Conte) and the green-frog (*Rana clamitans* Latreille) common in the locality of Bath, N. Y., where the epidemic of octomitiasis occurred, were found to be heavily parasitized with *Hexamitus*. The frogs had access to the water supply of the hatchery and must have naturally spread infection in it. However, a careful search through many prepared slides of material from parasitized frogs and fish has given what seems to be convincing proof that the parasite, *Hexamitus intestinalis* Dujardin, of the frog and *Octomitus salmonis* of the trout are specific for their hosts.

OCTOMITUS SALMONIS MOORE.

Octomitus salmonis Moore is a binucleate, bilateral, parasitic, octo-flagellate belonging to the family *Hexamitidae* of the order *Polymastigina*. It is an intestinal parasite causing the disease Octomitiasis in various species of trout. The actively swimming adult form, or trophozoite (1) is pear-shaped in outline, broad at the anterior end and bluntly pointed at the tail. The body in action is exceedingly mobile, but the pyriform outline is generally characteristic. In size the flagellate is minute, varying in length from 6 to 12 micra and in width from 3.5 to 5 micra.

The two nuclei (nuc.) are conspicuous at the anterior end. From their changing position, when the organism is moving, the nuclei appear to be connected with the blepharoplast complex, the mass of deeply staining granules in front of the nuclei, from which arise the three pairs of anterior flagella (fl. 1, 2 and 3). This complex consists of two sets of granules bilaterally arranged. In each set there is a forward granule, which lies at the base of a single flagellum (fl. 1) and two immediately behind, apparently fused, giving rise to the next two pairs of flagella (fl. 2 and 3). The pair of axostyles (ax.) extends backward from

this complex through the cytoplasm of the body and, because of their great flexibility, appear generally twisted or crossed during the movements of the organism. The axostyles extend to the tail and pass out of the body as the two posterior flagella (fl. 4) through two elongated grooves (gr.). Two darkly staining masses sometimes occur posterior to the nuclei on each side of the axostyles and may be interpreted as the parabasals of various allied forms of the *Hexamitidae* (14, 15, pb.). Their function is not clear.

Mode of Increase. Binary fission with a longitudinal splitting occurs abundantly and normally in both adult and juvenile stages (2, 9). The extremely mobile body becomes more nearly oval in outline and considerably enlarged. On the completion of mitosis—in which the nuclei are doubled—and the duplication of the blepharoplast complex, the two bodies pull away from one another from the anterior end posteriorly, each apparently becoming full fledged within the space of an hour.

Multiple fission is a common mode of increase in the encysted organism and the changes thus far observed in this process are suggestive of both a sexual and an asexual cycle in the life history. Encystment is frequent. The adult rounds up, decreases slightly in size, becomes quiet and secretes a cyst wall, which is thin and hyaline. During this process the nuclei increase in number and the flagella are lost (3 and 4). Further multiplication of nuclei follows rapidly (5), the cyst becomes considerably enlarged and finally breaks up into definite nucleated structures, resembling eggs or macrogametes. Structures resembling sperms or microgametes—minute, actively swimming bodies—have also been observed within cyst walls.

It is certain that the life history is extremely complex as regards the developmental phases of the cysts. From our present knowledge of the organisms in this group of protozoa, it is impossible to distinguish definitely between cysts producing gametes; i. e., copulation cysts, and those which may be designated as ordinary multiplication cysts which function in the asexual cycle or schizogamy. With the progress that has been made this season, however, the further interpretation of the life cycle does not present insurmountable obstacles.

Artificial Culture. Young stages have been secured under conditions of artificial culture and they indicate a free swimming,

motile, juvenile phase, in which growth and rapid multiplication by binary fission take place. By inoculating a highly alkaline and dilute fish broth with the adult organism, the growth stages shown in (8-12) were obtained. It is assumed that the adult passed quickly into a cyst, possibly a multiplication cyst, and this gave rise to numerous minute structures, resembling masses of deeply staining, coccus-like bodies that soon developed into the recognizable form of (8). The presence of a cytostome or "mouth" is apparent in the young (10), but it is a feature which is unrecognizable, if not lost altogether, in the adult stage. The last step which appears to be possible under conditions of artificial culture is shown by (12). Without doubt further transformation necessitates encystment within the intestinal and caecal wall, as suggested by the recent unpublished researches of Dr. H. S. Davis,* who simultaneously studied *Octomitus* during the past summer. His observations indicate that developmental stages also occur within the epithelial cells of the intestinal caeca and of the intestine. Such development apparently carries the organism through to the adult stage (7). It is possible that the young flagellates, motile and very mobile, slip into the soft epithelial tissue and there undergo final transformation.

Octomitus Salmonis a New Species. The organism in question is characterized by a binucleate, single celled structure with eight flagella. On the basis of these characters it obviously belongs to the family *Hexamitidae,* which includes such related genera as *Hexamitus* (13), *Octomitus* (14) and *Giardia* (15).

In determining the generic position of the new organism the criteria of classification are on the whole less easily applicable. The presence of a disk or cytostome is a structural feature to be reckoned with. It is conspicuous in *Giardia* and sharply sets it off from the other genera pictured. Schmidt (1920) argues that a cytostome is suggested for *Octomitus* by the behavior of the organism he described. His figures indicate a somewhat contracted structure of this kind. In the culture forms of the new organism (8-12) a cytostome is present, in the juveniles, but it is not apparent in the adults, although their behavior in this stage agrees with Schmidt's description of *Octomitus.* In *Hexamitus* no evidence of a cytostome has been adduced. By com-

* Loc. cit.

paring the new organism with the three representative genera in their various aspects of shape, type of nuclei, relation of axostyles and arrangement of flagella it seems clear that its generic position is in Schmidt's *Octomitus.*

The assignment of the organism to the genus *Octomitus* can hardly be made, however, without noting the confusion that exists in the use of the word. There has been a disposition to replace the genus name *Hexamitus,* established by Dujardin (1841) by the name *Octomitus,* on the ground that it expresses more accurately the number of flagellar appendages and to set off the free-living *Hexamita* from the parasitic forms (Prowazek, 1904, Dobell, 1909, Schmidt, 1920). An objection to this procedure has been raised with good reason by Swezy (1915). Clarity in nomenclature is given, however, in another direction. Moroff (1903) described an intestinal parasite of the rainbow trout and gave it the name *Urophagus intestinalis.* From the figures and descriptive matter the organism was doubtless identical with *Octomitus* and clearly not *Urophagus,* a name given to forms which ingested food particles through the hind end of the body, an activity which Moroff admitted he never observed. Alexeieff (1910) described similar parasites of marine fishes and, accepting Moroff's name, placed them in the genus *Urophagus.* They, also, judged by the figures and descriptions, belong to the genus *Octomitus.* By reducing *Urophagus intestinalis* Moroff to a synonym of *Octomitus intestinalis truttae* (Schmidt 1920) the intestinal parasites of the fish in so far as they have been described for the *Hexamitidae* now find a place in the genus *Octomitus.*

In assigning the name *Octomitus intestinalis truttae* to the intestinal parasite in the rainbow and brown trout, Schmidt (1920) has chosen to make it a subspecies of *Octomitus intestinalis* found in the rat (Prowazek, 1904) and a synonym of *Hexamitus intestinalis* Dujardin found in the frog. Certain differences between Schmidt's species (14) and the one found in our hatcheries (1) warrant classifying the American type as a distinct species. The European species shows relatively small nuclei, a difference in the relation of the axostyles in both adult and early cyst stages, and in the absence of grooves at the caudal end where the axostyles proceed outward, as the posterior flagella.

Because of these differences the species name of *salmonis* is proposed and our American form designated as *Octomitus salmonis*.

Schmidt states that he found the organism (14) widespread among the rainbow and brown trout fingerlings, in the lumen of the intestine and in the gall bladder, yet he failed to observe a pathological condition arising from their presence and concluded that the organism was a harmless commensal. The nature of the disease produced by the American species is different. Our species causes serious lesions in the intestinal epithelium, terminating fatally in many cases.

The parasites considered above are widely distributed in nature. *Giardia* is found in man, dogs, cats, rabbits, rats, mice and frogs. No authentic record is as yet at hand of its occurrence in fish. *Hexamitus* is common in frogs, toads and other batrachians and has been recorded for turtles and rats. *Octomitus* is distinctively a parasite of fish, occurring in both marine and fresh water forms.

REMEDIAL MEASURES.

With the isolation of the disease organism accomplished and the facts in the life cycle fairly well known, it is possible to consider preventive measures. Complete eradication of the disease can hardly be expected since resistant cysts are certain to be widely disseminated through one agency or another—by flies or other insects and by floating bits of excrement carried off in the current of the water. Nor is it to be expected that a disease of this nature, in which the organism passes a part of its life history within the walls of the intestinal tract of the fish, can be cured by administering drugs. Similar parasites (Giardia, Plate II, 15) in man and in cats have not responded successfully to treatment with carbon tetrachloride, * a chemical used with great success in the eradication of hookworm, nor with other drugs, emetine, B-napthol, etc. (Wenyon, 1915) used also experimentally in infections of Giardiasis. It would seem that hope lies in the adoption of preventive measures which will better control the disease and prevent epidemics.

Besides the adoption of better and more thorough sanitary

* From the unpublished researches of M. J. Hogue on the effects of carbon tetrachloride in infections of Giardia in man and in cats.

measures, it seems highly probable that a greater variety in kind of food will assist in combatting the disease. Such procedure is indicated by the examination of several 2-year and 3-year-old brook trout which had been removed as fingerlings from infected troughs at the Bath hatchery and placed in the spring pond, where they secured only natural food. It was found that the trout were still "carriers" of the organism, though not in numbers evidently to interfere with the normal functioning of the intestinal tract. These examinations were made in the summer and again at the time of the spawning function in the fall and their appearance at both times was that of normal and healthy fish.

*Sanitary Measures to be Tried Out.** In order to check the ravages of this and other diseases, it has been directed that all the State hatcheries be given a thorough course of disinfection this fall. The directions for this, which have been sent out, are as follows:

Every trough, race or other receptacle in which fish have been must be thoroughly sterilized. The ordinary tarring process used in all our hatcheries should be sufficient for this if particular care is taken to cover every surface which has been touched or will be touched by water with a complete layer of tar. There must be no holes in this coating and all corners and inaccessible spots must be thoroughly and carefully treated. This applies to plugs, screens and trays as well as to troughs. All brooms, brushes, feathers, cloths and similar implements used about the hatchery should be collected and destroyed, preferably by burning. All pans, spoons and other metallic implements or utensils must be thoroughly sterilized by washing with soap and hot water, prolonged boiling and the use of such disinfectants as chloride of lime. To be effective this sterilization must be thorough and universal and the progress of the work must be so conducted that at some moment of time after the shipping of the last fish and before the arrival of the first eggs there will be in the hatchery absolutely nothing which can carry the infection which has not been thoroughly sterilized. This is of prime importance, as one infected brush kept over through this period may reinfect

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* Excerpt from: Diseases of fish in State Hatcheries, State of New York Conservation Commission, Twelfth Annual Report for 1922, Legislative Doc. No. 29, 1923, p. 66-79, 2pl. fig. 10-14.

the entire hatchery. In hatcheries where fish are kept through the winter, it would be highly desirable, if possible, to make a rigid separation between the younger and older fish, and, under no circumstances, to permit any implement or utensil used in connection with the older fish to be used or brought into the building where the younger fish are to be raised or are kept. For instance, at Cold Spring hatchery, nothing used in connection with the outside races should be permitted to be brought into the hatchery building and the hatchery building should be put through the course of sterilization above mentioned. There is no doubt but that the adult fish at these hatcheries harbor the disease, so that danger of reinfection of the rearing troughs must always be present.

IMPORTANCE OF THE STUDY.

Because of its prevalence octomitiasis is unquestionably a disease of considerable economic importance. The vested interests in state, federal, private and commercial hatcheries devoted to trout rearing are extensive and their combined losses enormous. The greater susceptibility of brook trout over other species limits the output and jeopardizes the future culture of this favorite game fish.

The study of this disease is still in its initial stages, the work of a single season, and much remains to be done before a definite mode of treatment can be prescribed. Further study is essential on the morphology of the organism, on its mode of increase, its transmission and the general or special conditions affecting its pathogenicity.

Aside from the benefits to be derived from this study in the field of fish culture, there are those which are directly applicable to human problems in the field of comparative medicine. For example, *Octomitus* in the fish and *Giardia* in man are closely related protozoa. Both are octo-flagellates that parasitize their hosts in the intestine with attendant symptoms of dysentery. It has been noted that in case of infected fish *Octomitus* penetrates the wall tissue of the intestine where it passes certain of its developmental stages, and that in cases of heavy infection such parasitism is accompanied by a general disintegration or breakdown of tissue resulting in the fatal sickness. Observations of this kind, as shown by *Octomitus,* should throw light on the

behavior of the similar organism, *Giardia*, but which from the nature of the problem in the human host cannot be so readily investigated.

Other aspects of the study of parasitism in the fish of importance in comparative medicine have to do with double or even multiple infections. These, also, have been observed in the fish. *Octomitus* is clearly associated with a species of *Entamoeba*, similar to that occurring in man. Yeasts with branching habit occur frequently and suggest, from their abundance, a possible role in the progress or decline of octomitiasis.

A hatchery in which infection is severe affords unlimited opportunity for research in this field of parasitology and, because of its bearing on the human problem, offers a fertile field both for study and experimentation.

SUMMARY.

Trout hatcheries suffer annual losses of fish from octomitiasis, a disease caused by a minute protozoan flagellate (*Octomitus salmonis* Moore) parasitic in the intestine of the fish.

Lesions occurring internally in the intestinal wall and in the caeca are occasioned by the penetration of the organism into the wall tissue, where certain developmental stages take place.

All species of trout are susceptible to the disease, though the susceptibility of brook trout over other species is pronounced and doubtless explains the inability to rear this species at some of the older hatcheries.

Mortality decreases with increase in size, so that an epidemic among the smaller fingerlings may result in heavy loss. The survivors of the disease may become "carriers."

Transmission of the disease probably occurs by cysts, highly resistant structures, which pass to the exterior in the excrement and become widely disseminated through various agencies, or through lack of proper sanitary precautions. Although somewhat similar parasites occur in the frog, the observations incline to the belief that each type is specific for its host.

Octomitus salmonis Moore is a binucleate, bilateral, parasitic octo-flagellate, belonging in the order *Polymastigina* and in the family *Hexamitidae*. The genus has been previously described for

the single European species, *Octomitus intestinalis truttae*, common in the rainbow and brown trout.

The ordinary adult form or motile trophozoite is pyriform in outline, broad at the anterior end and bluntly pointed at the tail. Its length varies from 6 to 12 micra and its width from 3½ to 5 micra. Its neuro-motor system resembles that of its close allies, *Hexamitus* and *Giardia;* the two nuclei are anteriorly placed and presumably connected with the six anterior flagella and with the two axostyles, which sweep outward at the caudal end as the two posterior flagella. Parabasals are not a constant feature. A cytostome is not clearly marked in the adult form, though it is a distinct feature of the juveniles.

By artificial culture methods motile juvenile forms have been obtained, but development by artificial means has failed to show the adult form. It is assumed that further development requires encystment conditions presented by the wall layer of the intestine.

The mode of increase is by binary fission with a longitudinal splitting and by multiple fission. In the latter case the multiplication of nuclei follows rapidly on encystment of the adult and structures are produced which strongly resemble micro and macrogametes.

Preventive measures should follow the lines of thorough sanitation. Internal medication is impracticable and hope lies in the adoption of thorough sterilization methods, which should keep the disease in check.

Octomitiasis is a disease of considerable economic importance because of the limitations and restrictions it places on the output of the trout hatcheries, representing large investment of capital in state, federal, private and commercial hatcheries.

The study of the disease from the standpoint of comparative medicine is suggestive of beneficial results in terms of human economy.

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EXPLANATION OF PLATES.

All figures, excepting Plates II-14-15, were outlined with a camera

lucida from permanent preparations, under oil immersion 1.5, ocular 10-X. Smears were made of the intestinal contents and treated by the wet Schaudinn method or in Zenker's fluid. Stain: iron-haematoxylin, or Delafield and eosin following Zenker's fixative.

Abbreviations: *nuc.*, nucleus; *fl.* 1, first flagellum; *fl.* 2, second flagellum, *fl.* 3, third flagellum; *fl.* 4, posterior flagellum; *ax.*, axostyles; *gr.*, groove; *cyt.*, disk or cytostome; *pb.*, parabasal bodies.

PLATE I.—*Octomitus salmonis.*

1. Typical adult, motile, individual showing six anterior and two posterior flagella, nuclei, and axostyles. Found chiefly in the fore-intestine when infection is most severe.
2. A stage in the longitudinal division of the adult form. This stage and the preliminary ones leading to it were frequently observed on smears of fresh material, and represent a common mode of multiplication.
3. A newly encysted adult *Octomitus.*
4. A stage in encystment later than in 3.
5. A cyst at stage later than that in 4, showing multiplication of nuclei—perhaps a phase in the sexual cycle.
6. Advanced stage of that shown in 5, showing formation of what are perhaps the eggs.
7. An encysted form which has developed within the epithelical cells of the intestine—perhaps a "*Hexamitus stage.*"
8. Young *Octomitus.* Early stage showing single flagellum and attachment disk at bottom.
9. Longitudinal division of young form, a method of rapid increase of individuals. Attachment disk shown at right of upper individual.
10. Side view of young form, a slightly older than that in 8, showing strong resemblance to young *Giardia.* Attachment disk at bottom.
11. Further advancement of young form, showing two flagella.
12. Advanced young form with three flagella. The attachment disk has disappeared and the prolongation at the bottom suggests the future trailing flagella.

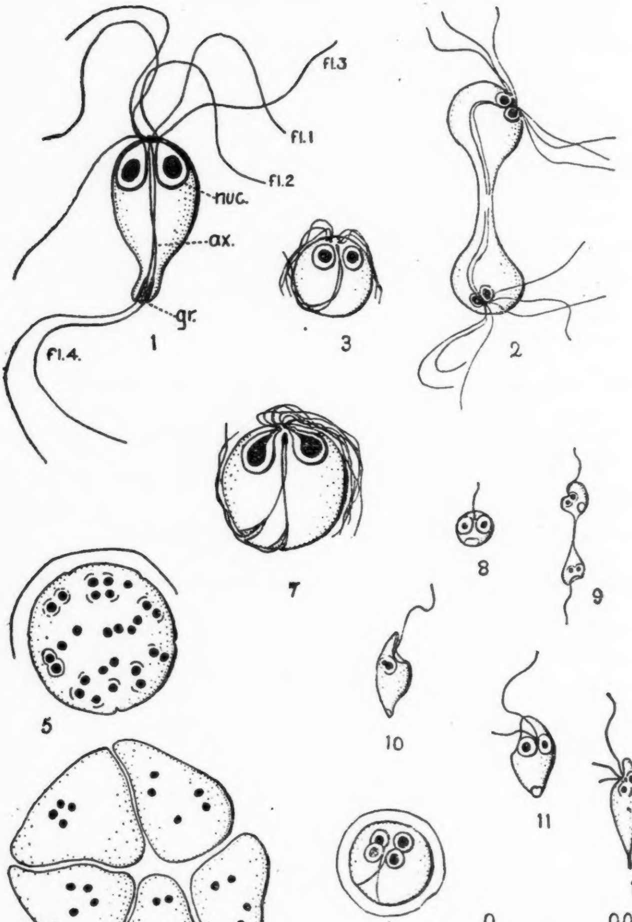
PLATE II—*Hexamitidae.*

13. *Hexamitus intestinalis* Duj. Specimen from intestine of a frog.
14. *Octomitus intestinalis truttae* Schmidt. After Schmidt, W., 1920.
15. *Giardia enterica* Grassi. Human parasite. After Kofoid, C. A. and Swezy, O., 1922.
16. *Octomitus salmonis.* Forms encysted in tips of epithelial cells sloughed off intestinal tract. a, single individual; b, division of individual in the encysted stage.

APPENDIX.

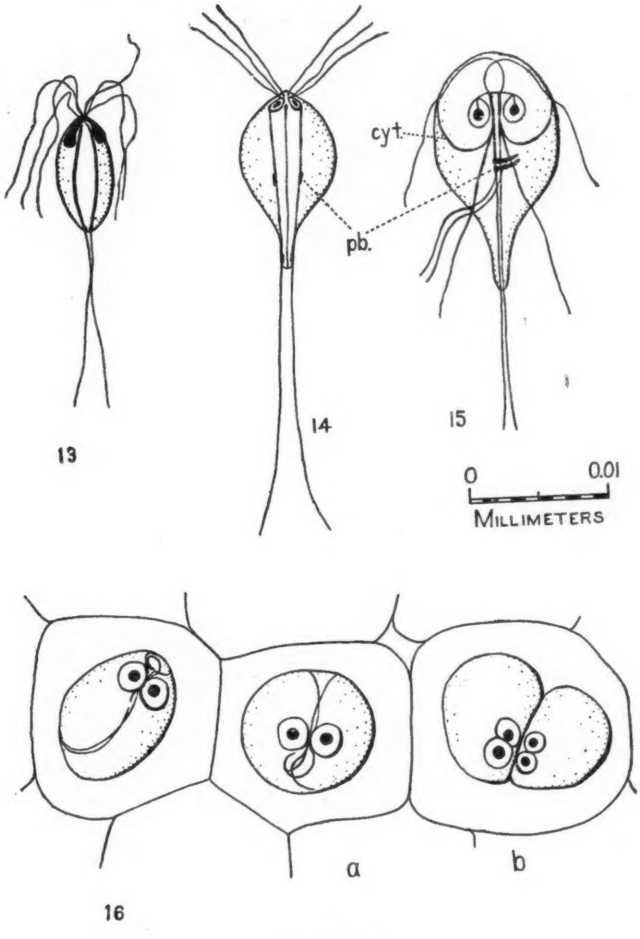
The data in the tables of Dissolved Oxygen Determinations and Chemical Analysis are appended by courtesy of the Commis-

PLATE I.



OCTOMITUS SALMONIS.

PLATE II.



HEXAMITIDÆ.

sion's staff; Mr. Herbert Ant, chemist; Mr. Summer Cowden, field superintendent; Mr. Henry Davidson, hatchery superintendent, and Mr. Russell Suter, senior assistant engineer.

Attention is called to the very low oxygen content at the Bath Hatchery; to sample 18 indicating that the critical point was approached when the oxygen supply was about one part per million (10 per cent saturation) at 9° C.; and to sample 19 showing the correlation between low oxygen and high CO^2 when death occurs. These samples were taken primarily to determine the minimum oxygen requirements of fish.

DISSOLVED OXYGEN DETERMINATIONS

Number of sample	Source[1]	Dissolved oxygen, parts per million	Percent saturation	Temperature	Date	Remarks
					1922	
1	Main reservoir near outlet	1.71	15.8	12	May 2	
2	Main reservoir at overflow	.75	6.6	10	May 2	
3	Large spring in main reservoir	.42	3.7	9	May 2	
4	Aerator	2.10	19.8	11.5	May 2	
5	Well No. 3	1.20	10.4	9.5	May 2	
6	Source No. 2 near shore	2.03	20.2	15.5	May 2	
7	Source No. 2 at outlet	.65	5.6	9	May 2	
8	Source No. 4	2.36	23.4	15.5	May 2	
9	Source No. 5	.21	1.8	9	May 2	Hydrogen sulphide present.
10	Water at foot of flume	2.10	19.5	11	May 2	
11	Water from head trough in hatchery, pipe direct from aerator	1.90	17.6	11	May 2	
12	Water from foot of same trough after passing through fish	1.70	15.6	11	May 2	
13	Water from head of trough in hatchery	2.10	18.5	9	May 3	
14	Water from foot of same trough	1.90	16.6	9	May 3	
15	Head of outdoor trough, mixture of all water	1.60	14.5	11	May 3	
16	Foot of same trough, after water passes through fish	1.60	14.5	11	May 3	
17	Water in hatchery running through trough in which 10,000 brook trout were placed	1.70	14.8	9	May 3	Trace CO_2.
18	Same as sample No. 17 after water supply at head of trough has been shut off 14 minutes	1.18	10.1	9	May 3	Fish uneasy
19	Same as No. 17 after 28 minutes	.75	6.48	9	May 3	A number of dead fish, 12% CO_2

[1] The principal supply pool is fed from large springs; water is piped to aerator and thence to hatchery or carried to hatchery in wooden flume; additional supply from source No. 2, and two flowing wells, sources No. 3 and No. 4; another well, source No. 5 not used.

CHEMICAL ANALYSIS.

	Parts per million.
Odor	1 vegetable
Color	trace
Turbidity	clear
Nitrogen as free ammonia	.028
Nitrogen as albuminoid ammonia	.016
Nitrogen as nitrate	trace
Nitrogen as nitrate	1.40
Oxygen consumed	0.10
Chlorine	7.00
Total hardness, soap method	190.00
Alkalinity	160.00
Total solids in solution	224.00

Discussion.

MR. C. O. HAYFORD, Hackettstown, N. J.: This paper of Dr. Moore's is exceedingly interesting to me. I have often encountered the same trouble, as the fish from every appearance had the same symptoms as described by Dr. Moore. I lost this year, in a single night, from one pond, 1,700 brook trout fingerlings. My scientific assistant, Mr. Foster, has made some progress in investigations, but we have not the means and experience of getting at this subject that Dr. Moore has. It may be interesting to know that when we take the artificial food entirely away from affected fish and give them their natural food, the mortality greatly diminishes. Our trouble generally comes when the black birds make their first appearance. At first we were inclined to believe they might be carriers of the trouble. Examinations of cultures from the excrement, blood, etc., have been of no value thus far We also found, as Dr. Moore stated, that the greatest mortality is among the brook trout. We have very little trouble with the rainbows, and this is the first year the brown trout contracted it to any extent. One interesting point about the brown trout is that a little brown spot appears on top of the head just back of the eyes. Soon after this spot becomes visible the fish generally starts a spiral whirl along the sides of the ponds and is finally carried against the overflow screen. We have a great many springs boiling out of the ground that supply our hatchery. These springs vary in oxygen from two and one-half to eleven parts per million. Carbon dioxide zero to fourteen parts per million. Three years ago ponds carrying the highest percentage of carbon dioxide gave us the most trouble. This year they gave us the least. Therefore we can not at present attribute it to the carbon dioxide.

MR. W. T. FOSTER, Easton, Pa.: I should like to ask Dr. Moore if she occasionally found some of the infected trout turning a darker color, with the gills light instead of reddish?

DR. MOORE: Yes, I believe I can say that. I thought that might be attributable, however, to variation in the natural coloration; but I have

noticed that some of the badly afflicted fish are quite black—notably the smaller ones.

MR. FOSTER: It is suggested to me that possibly the liver may be responsible. I have been told by authorities on the feed of animals in zoological gardens that the feeding of liver to those animals produced conditions quite similar to those that Dr. Moore has described.

DR. MOORE: The fact that this disease becomes pronounced when they are about six weeks old, shortly after artificial feeding commences, leads me to suspect that the trouble may be aggravated by the kind of food given, but this is the first season I have had them under observation. We have secured many leads on which to work in following years, and that phase of the problem should certainly be studied.

MR. J. W. TITCOMB, Hartford, Conn.: We apparently had a disease of that description at a rearing plant where we were taking fish from two different hatcheries; and we attributed it to one of those hatcheries. First we thought it might be blamed on the brushes, so we had them sterilized. Whenever we found a fish boring we let it go into the stream below, and although the water was largely from this same rearing plant, the fish seemed to recover. In fact, we had quite a large school both above and below the rearing plant that thrived splendidly in the natural stream.

DR. MOORE: In a similar situation I found a trout about 7½ inches long carrying the organism. The chances are that it had eaten an infected fish that had been discarded.

MR. TITCOMB: Do you think there would be danger of spreading the disease by planting trout from a trough in which the disease you have described had been discovered?

DR. MOORE: From the standpoint of our knowledge of hygiene and sanitation, the best plan to follow, it would seem, would be quarantine; that is quite contrary to our practice.

MR. G. C. LEACH, Washington, D. C.: Do you think the disease may be attributable to unsanitary conditions in feeding?

DR. MOORE: Not to unsanitary conditions, because at this hatchery where the epidemic has occurred annually the sanitary conditions are excellent.

MR. LEACH: You spoke of the appearance of the disease about six weeks after the fish had hatched. I would think it possible that the fish were fed a little too soon, causing a form of indigestion.

DR. MOORE: That is possible. They were hatched in February and the disease became apparent the first of April.

MR. LEACH: That would be about right, then; feeding would be started at about four weeks of age, or possibly a little earlier. At the Manchester, Iowa, station they apparently had that disease three years ago; and they have been starting their fish on beef heart and later on feeding them sheep liver. I am told that last year they had absolutely no trouble.

DR. MOORE: That is quite remarkable; because at one of our hatcheries where they feed along similar lines the disease is present, though not in epidemic form.

MR. LEACH: I was wondering if the melting snow would have anything

to do with the water becoming infected. At Manchester we get very little surface water, if any, in the spring; but it might be surface water that seeps down through the soil and eventually enters the spring and flows out.

Dr. Moore: There is some seepage or ground water entering the spring at this hatchery.

Mr. Leach: That condition may have been different at Manchester this last year, and it might explain why they did not have any loss when in the previous two years there was a loss.

Mr. Titcomb: I had something to do with this hatchery for a number of years. Undoubtedly they have had this same trouble for a great many years, varying of course in severity; some years the loss would be very much larger than others. This flume that Dr. Moore refers to was put in because I had a great prejudice against carrying water underground to hatcheries; I will never put a pipe underground when I can conduct the water on the surface. The idea of the flume is to get the water into the air and thus secure more oxygen. In the two seasons after that flume was introduced we had very remarkable results in the production of fingerling trout at this hatchery.

Mr. Hayford: I might add one thing more in regard to the question Mr. Leach has asked. With us, it varies from the time the fish have been feeding from two to eight weeks. We have very little trouble after the middle of June. Generally we have been able to control the epidemic by changing the water and food supply. Our experience at Hackettstown has taught us that the fresher our food supply the better success we have. In the past we have fed a great deal of frozen butterfish. This year we have fed very little of it, depending largely on sheep plucks and beef livers with a liberal amount of natural insect food given at least once a week to the brown and brook trout; the result has been beyond expectations.

Mr. Leach: I think Mr. Hayford's point is a good one—that the food of the fish probably has much to do with it. I think that overcrowding also has its effect. What size hatching trough do you use, Mr. Hayford?

Mr. Hayford: We have all sizes, but prefer those 12 feet long, 15 inches wide and 9 inches deep, in buildings, and as many larger ones as we have room to raise fish up to 8 to 10 inches long. The New Jersey Commission does not believe in planting fish under two inches. We could hatch 20,000,000, but as we do not plant fry we only hatch four to six million. We put the fish into ponds at all sizes, from fry to two and one-half inches. In one pond there will be 10,000 fish without any trouble; in another, with the same water and the same conditions generally, we will have all kinds of trouble. We are much interested in this food question. Where we get perfectly fresh sheep plucks, of light color, which every practical fish culturist recognizes as an indication of their fitness, we have no trouble.

Mr. Leach: You think the trouble is brought about more by the food than by overcrowding?

Mr. Hayford: After running them in different numbers from 1,000 up to 10,000, and often having more trouble with the 1,000 than with the 10,000, I am satisfied that overcrowding has very little to do with it. I made

a great many tests with different members. We have kept pretty close watch on them as far as the food is concerned. Our main idea is that we can have a certain number of fish up to a certain size as long as they all get sufficient quantities of food. If a practical feeder will take plenty of time in feeding there should be a minimum of trouble.

Mr. Titcomb: I just want to give one theory on this whole subject of fish diseases where we raise fish intensively. We know that if we do not take care of ourselves and we happen to be carrying some bacteria in our bodies, we may yield in our weakened condition and become ill. Extend this condition and you have an epidemic like the influenza. With the trout there may be a number of factors contributing to the presence of disease. It may be a lack of oxygen, or something in the food. Anyway, the fish become weakened and they yield to the bacteria or rather protozoa in their bodies.

A NEW AND PRACTICAL DEVICE FOR TRANSPORTING LIVE FISH.

By Edgar C. Fearnow
Superintendent of Fish Distribution, Bureau of Fisheries, Washington, D. C.

The process of evolution in fish distribution has, in the past, been very slow indeed. In the earlier days the Bureau's distribution cars carried hatching equipment, and everything was designed on a large scale—large boilers, air pumps large enough for several thousand cans, large tanks for carrying an extra supply of water, and other equipment in proportion, and few changes have been made. The 10-gallon milk can selected for use, and still employed to a great extent, weighs 22½ pounds without the lid, the weight being sufficient to crush the rim and neck if an empty can be dropped in an inverted position from a baggage car to the platform.

Prior to the late war the Bureau's distribution cars were moved at an average cost of about 14 cents per mile, as in many instances free transportation was secured. During the war the rate was increased on Federal-controlled roads to ten full fares and the cost mounted to 36 cents per mile on interstate shipments. This increase of approximately 150 per cent, still operative, has been most serious, since the allotment of funds for distribution purposes has remained practically the same for a number of years notwithstanding an enormous increase in the number of applications received annually. The necessity of economical and practical means for transporting live fish, although recognized some time ago by the Bureau, was most strongly emphasized by these circumstances. Moreover, it was realized that if the transportation problem could be solved there would be corresponding benefits in other phases of fish-cultural work. In order to meet the difficulties presented the writer caused to be conducted a number of experiments in carrying fish with a view to finding a practical method of filling the applications filed with the Bureau with the limited funds available for that purpose.

The shipment of live fish is attended by many difficulties and great expense. The water in which the fish are carried must be maintained within a few degrees of a certain temperature and must be aerated to replace the oxygen which is rapidly lost and which

is necessary to the life of the fish. Experiments in connection with the use of the evaporation jacket described in an article entitled "A New Method of Carrying Live Fish," and published in the Transactions of the American Fisheries Society in 1921, convinced the writer that the large amount of water used in transporting fish could be materially reduced.

After numerous experiments it was found that with means for controlling the temperature, fish could be carried as satisfactorily in eight or ten inches of water, the ordinary milk can being used, as in sixteen inches of water. These experiments were conducted on two of the cars and extended over a period of several months. One of the car captains used an ordinary garbage can 13 inches high and 12½ inches in diameter, carrying as many fish therein as were handled in the regulation can. Another captain carried fish from Marquette, Iowa, to New Mexico, in 8 and 10 inches of water.

INCEPTION OF IDEA.

Practically every individual who has been connected with the distribution of live fish has observed one or two trout or bass inadvertently left in the bottom of a fish can in a very small amount of water. Fish in such condition have been known to survive for a number of days without attention provided no sudden change of temperature occurred. It has also been noted that fish in landlocked ponds and pools along streams survive months in a very crowded condition when a large surface of the water is exposed to the air. The 10-gallon can now in use carries a depth of sixteen inches of water, and when the fish are poured from one of these cans into a tub or lard can where the water is shallow they seem to do much better. In fact, it not infrequently occurs that a 10-gallon can of fish is poured into a shallow fifty-pound lard can and shipment made a considerable distance with good results.

Certain species most difficult to transport successfully, such as trout, habitually seek the bottom of the container where the water is less affected by the absorption of the oxygen of the air. Since a considerable body of water is less affected by change of the atmospheric temperature and does not become polluted as quickly as a smaller volume, it has been customary to fill the containers comparatively full, notwithstanding the desirability of carrying fish near the surface of the water.

With the idea of devising a practical means for carrying fish in a small volume of water the writer conducted the following experiments:

(a) During the month of November, 1921, 300 3½-inch black bass were delivered to the Bureau in four 10-gallon cans by one of its distribution cars. These fish were held in an aquarium several days, and on November 21, 1921, 75 of them were placed in a lard can containing 8 inches of water and held from 10:30 a. m. until 3:00 p. m., without aeration. The air and water temperatures at the beginning of the experiment were 56° and 50°, respectively; at the end of the experiment 58° and 50°, respectively. At the same time 75 fish were placed in a standard 10-gallon can in 14 inches of water and held for the same length of time. At the end of the experiment fish in both cans showed signs of needing aeration. No loss whatever occurred in connection with the experiment.

(b) At 1:15 p. m., the same day, 25 3½-inch bass were placed in a standard 10-gallon can containing 1½ pints of water, air temperature 58° and water 50°. These fish were held until 4:15 p. m., when the experiment was discontinued with no loss of fish.

(c) On November 22, 1921, at 9 a. m., 50 fingerling 3½-inch black bass were placed in a lard can in 1 quart of water; water temperature 50° and air 54°, and held until 1:00 p. m. The temperature of the air at the end of the experiment was 63° and water 58°. These fish by being held in shallow water provided their own aeration. Their dorsal fins were slightly out of the water and when they became restless their motion furnished the required aeration. Twenty-five fish of the same size were placed in a 10-gallon can in the same amount of water with similar results. At 1:00 p. m., the fish in the two cans, 75 in number, were placed in one can in 1 quart of water. In order to maintain an even temperature a moistened jacket was placed over the can and the 75 fish held therein until 2:00 p. m., when the experiment was discontinued and the fish delivered to an applicant. The air and water temperatures in the beginning were 63° and 50° respectively, and remained practically the same during the hour the 75 fish were in the can.

It became apparent that fish could be held in a very small volume of water, provided means could be found for controlling the water temperature and removing the pollution. While the swimming efforts of fish can be utilized to provide aeration, it would not be possible to handle them in shipments over rough roads in so small a volume of water. To permit this to be done, an aerating pan was designed which would hold the fish near the surface of the water with the object of overcoming difficulties heretofore experienced and making it possible to ship live fish for quite a distance, with substantially no attention, suitable water temperature and aeration being automatically provided.

A rough model of this device was constructed on December 19, 1921. On that date 20 6-inch albino brook trout were placed in the aerating pan which was submerged one inch in seven inches of water, the outside container being provided with an absorbent jacket. The experiment was begun at 9:00 a. m., with water temperature 40° and air 50° F. The can was held indoors without aeration until 4:30 p. m., when the temperature of the water had gone up to 43° with the air 50°. As the fish were in excellent condition at that time they were placed in an automobile and taken to the writer's home, 7½ miles in the country, and held over night without attention. The consignment was returned to the Bureau and placed in the aquarium at 9:30 a. m., on December 20.

The appliance was delivered to one of the distribution employes and taken to White Sulphur Springs, West Virginia, for the purpose of shipping adult trout to the Washington aquarium. On January 5, 1922, the can containing five adult brook trout in excellent condition arrived at Washington at 5:00 p. m., the shipment having left White Sulphur Springs, West Virginia, at 8:30 a. m., the same day.

DESCRIPTION OF DEVICE.

Broadly stated the device is a container having a supplemental compartment, the container to hold a body of water in which the supplemental compartment is partly immersed. This compartment is provided with means through which water from the main body may circulate and be aerated. The purpose of the device is to carry adults and fingerling fish in the shallow inner compartment where the water is purest and to utilize their activity for the aeration of the water. Means are also provided for controlling the temperature of the water. The receptacle may be used without the compartment for carrying fry, as in this case the problem of aeration is insignificant.

The container consists of an outside receptacle with a series of perforations or vents somewhat below the upper edge for the purpose of admitting air into the interior in case something is placed on top of it. The compartment fits into the outer receptacle and is held in place by flanged edges which rest upon the shoulder of the outer receptacle. The bottom of the lower tray has a number of small apertures, and its sides taper from top to bottom more rapidly than the sides of the outside receptacle, thus providing an

air space or splash chamber between the sides of the bottom tray and the outside receptacle. The bottom of the upper tray is also perforated with a series of small apertures, and has a large central opening to permit inspection of the interior.

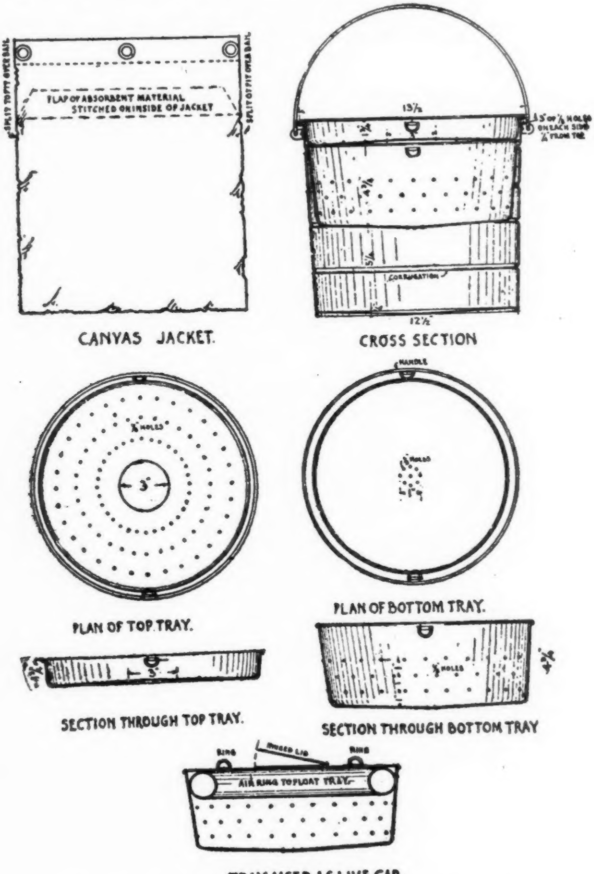


Fig. 1.—Jacketed can for transporting live fish.

In use the receptacle is partially filled with water of a predetermined temperature until the depth in the bottom tray is sufficient to submerge the fish. An absorbent jacket is then drawn over

the container and its inside flap folded in and down over the edge of the outside receptacle. The upper tray is placed within the receptacle and the inner flap of the absorbent jacket is thus held in position between the outer receptacle and the upper tray, the width of the flap being sufficient to permit it to extend below the bottom of the upper tray. The jacket is then moistened and is maintained in that state by the wick-like action of the flap. The evaporation of moisture in the jacket absorbs the atmospheric heat, thus keeping the water sufficiently cool for warm water fishes.

AERATION.—HOW ACCOMPLISHED.

The automatic aeration is accomplished in the following manner: The fish in the bottom tray are compelled to remain near the surface of the water, where the greatest amount of oxygen is present When the container is in motion its swaying and jolting will cause the water in the outer receptacle to move from side to side. Since water presses equally in all directions, and the body of water in the lower part of the outer receptacle entirely fills the space between its bottom and sides and the bottom of the lower tray, this body of water can move only by virtue of the air space of the splash chamber between the sides of the outer receptacle and lower tray. The result is that a portion of the water will be forced up into the air space with considerable violence by the mass movement of water in the lower part of the outer receptacle, and will pass in small jets from the space into the lower tray, not only through the perforations in its sides, which are below the normal surface of the water, but also through the perforations which are above the surface of the water, falling therefrom through the air into the lower tray and becoming aerated by its passage through the air.

The amount of water thus forced into the lower tray will, because of the pressure to which it is subjected, be somewhat greater than the quantity that will flow out by its own weight through the limited number of perforations below the surface, with the result that the water level in the lower tray will be raised until a point is reached where the perforations submerged by the water within the lower tray are sufficient to compensate for this forced injection. In this way a higher level of water is maintained and it affords the fish greater freedom of action while the vessel is in motion.

This method of aeration permits the carrying of fish in very shallow water in a comparatively quiet state, since the water in the fish compartment is not disturbed by violent waves having behind them the inertia of the entire volume of water in the vessel. The artificial water level produced by agitation, either manually or by the motion of the vehicle, creates a gentle current through the bottom apertures of the tray which carries all excrement to the bottom of the outside receptacle, where it remains on account of the comparative stillness of the water at that point.

When the container is stationary the water within the lower tray returns to its normal level, to be determined by the character of the fish to be shipped. When shipping large fish as distinguished from fry the water should be of sufficient depth to permit the fish to swim about with their dorsal fins slightly exposed.

When the supply of oxygen in the water becomes depleted the fish begin to feel discomfort, which manifests itself in increased activity and results in the splashing of the water because of its extreme shallowness.

The functions of the upper tray are as follows:

1. To act as a cover and baffle plate whenever the motion is sufficient to cause the water to splash against it. The perforations are of such dimensions that the water cannot pass through in sufficient volume to slop over but will percolate back into the tray, becoming aerated by the process.

2. The upper tray also serves as a receptacle for carrying ice when cold water fishes are handled during the warm summer months. The perforations permit the ice water to drip into the bottom tray, carrying with it a large supply of oxygen. Under such conditions the outer flap of the absorbent jacket is drawn over the ice and retained in position by a drawstring.

SIPHON.

The object of the siphon is primarily to remove sediment and pollution from the pail and secondarily to provide means for maintaining the water level at a substantially fixed point, and incidentally to moisten the canvas jacket. These results are accomplished by combining with the pail a siphon so arranged that by tilting the pail, or by addition of water to the container, by the melting of ice or otherwise, the siphon may be submerged and caused to operate to remove sediment and polluting matter and to reduce the water level to a predetermined quantity.

The siphon may be caused to function regardless of the water level, whenever it is desired to remove polluting matter, by simply

tilting the container until the siphon is completely submerged and tilting it back again when the desired result has been accomplished. This arrangement also makes it impossible for the container to be filled too full.

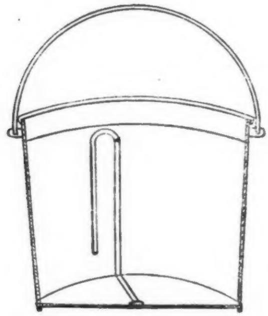


Fig. 2. Cross section showing automatic siphon.

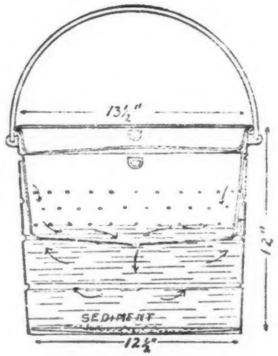


Fig. 3. Cross section showing water circulating through tray.

It should be obvious to anyone that it is desirable to carry fish under the most sanitary conditions possible. While messengers have instructions to carry siphons and remove pollution from cans when necessary, such instructions cannot always be carried out. The cans are often so arranged that it is difficult to use the siphon, as for example, on the fish cars where the compartments are lower than the aisle of the car and the cans are close together. The rubber tube siphon sometimes employed is obsolete in that its use is impracticable in most instances, and besides it is insanitary since it is usually started by suction applied by the mouth.

The automatic siphon permits the removing of sediment and a complete change of water in the minimum amount of time, which is quite important when close train connections are to be made. With this device in use on the distribution cars it will be possible for one man to change water on a full carload of fish while at a junction point.

PRACTICAL RESULTS ACCOMPLISHED.

The jacketed lard can, the forerunner of the self-aerating pail, was used by practically all the southern stations and on the distribution cars in shipping warm-water fishes last year. The ship-

ment of trout from White Sulphur Springs, West Virginia, to Washington, D. C., previously referred to, was in an improvised pail of the new type. It was during the spring of 1922 that the Bureau arranged with the Naval Gun Factory for the manufacture of 65 pails embodying the ideas set forth in this paper. These pails were made by hand and delivered to the Bureau in small lots from time to time. Several of the Bureau's cars have used them, carrying five in the space occupied by three of the regulation cans, with very satisfactory results.

The following are typical examples of shipments of fish made with this device:

1. To meet an urgent call for adult rainbow trout two of the pails were sent to White Sulphur Springs, West Virginia, with instructions that 12 adult fish be forwarded to Washington, D. C., without an attendant. The consignment reached Washington on the morning of March 20th, having been shipped the previous evening. The fish were brought to Central station about 8:00 a. m., where they remained without attention until 11:00 a. m. when they were conveyed to the Zoological Park and held until 3:00 p. m. Each can contained 6 rainbow trout, the fish being 11 inches in length.

An item in the Fisheries Service Bulletin of May, 1922, contained the folloing report of a shipment made by the Bureau:

2. "On April 8th a shipment of adult black bass for breeding purposes was forwarded from Washington, D. C., to Edenton, North Carolina. The fish, 60 in number, averaging about 2 pounds each, were carried in 8 of the regulation 10-gallon cans, each containing about 8 gallons of water, 5 fish per can; one 20-gallon can with 10 fish; and two of the new type of vessel with 4 gallons of water and 5 fish per can. A dipper was used at intervals to aerate the water in the old type vessels. No special attention was given the fish in the new type except to lift the tray during a delay at the transfer point. A satisfactorily uniform temperature was maintained in these pails throughout the 13-hour trip and the fish were delivered in good condition. Three fish were lost in the regulation cans."

3. To fill an application for fish of the Potomac Anglers Club, 1,400 1½-inch rainbow trout were shipped by express from White Sulphur Springs West Virginia, to Washington, D. C., the consignment being contained in two pails. The shipment left White Sulphur Springs on the evening of April 14th and reached Washington at 8:30 a. m. the next day. The following letter dated April 18, 1922, on the subject was received from Mr. P. E. McKinney, chairman of the organization's committee on fish stocking:

"With reference to the test conducted by the writer on the handling of brook trout in the new type of Fearnow self-aerating fish pails, a shipment of brook trout, consisting of two pails containing approximately 700 fish each was received by the writer at Union Station on April 15th, about 8:30

a. m. One of these pails contained fish which had been fed within 48 hours of shipment, whereas the other contained fish which had been fed within 24 hours of shipment in order to determine the comparative efficiency of fish shipment under the two conditions.

"Some delay was experienced in getting the fish to the stream, on account of tire trouble with the automobile used to transport them, and second, on account of extremely bad road conditions in Virginia, the fish having been en route for over two hours. About 11 o'clock the fish were distributed in several localities, being placed in meadow stream feeders to the main creek.

"Both lots of fish were in fine shape when placed in the stream, the total of dead or injured fish in the shipment being less than 3 per cent, which would compare very favorably with any shipment of fish which the writer has previously handled in the old type of containers. The condition of the fish which had been fed 48 hours previous to shipment was decidedly better than those which had been fed 24 hours previous to shipment, the percentage of dead and injured fish in this lot having been practically nothing.

"The new type of fish pail is considerably easier to transport and is not subject to splashing and slopping water when transported over rough roads and requires no attention by aerating, as is necessary with the old type of containers."

4. Fifty 4-inch rainbow trout produced at Manchester, Iowa, were placed on Fisheries Car No. 8 at 3:00 p. m., on April 17, 1922, temperature 45°, and were poured into one of the special fish pails, the depth of the water in the tray being 1½ inches. At Drummond, Wisconsin, at 3:05 p. m., on April 18, the fish were delivered to an applicant in good condition. These fish had been held in the compartment for quite awhile without special aeration.

5. Five hundred 1½-inch brook trout produced at Manchester, Iowa, and delivered to Fisheries Car No. 8 at 4:00 p. m., on April 17, 1922, temperature 45°, were placed in a pail. These fish being small enough to pass through the perforations of the tray, it was decided to carry them in the outer receptacle. The car arrived at Ashland, Wisconsin, at 4:25 p. m., on April 18, where the fish were delivered to an applicant in good condition.

6. Thirty thousand whitefish fry were delivered to Fisheries Car No. 8 at Duluth, Minnesota, at 4:00 p. m., May 9, and poured into a pail not equipped with the fish tray, the tray not being intended for use with small fish. No ice was used during the trip. The temperature of the fish compartment of the car dropped from 42° to 38°. These fish were planted off Portage Entry near Chassell, Michigan, in good condition, having been in the pail 16 hours without special aeration.

7. Five thousand lake trout fry produced at Duluth, Minnesota, were placed in one of the fish pails on Fisheries Car No. 8, at 3:00 p. m., on May 16. The temperature in the fish compartment was gradually reduced from 45° to 40° during the trip. These 5,000 lake trout fry were in the pail 21 hours and were planted in Lake Superior at Munising, Michigan, at noon May 17, in good condition. The captain of the car makes the following statement with reference to this shipment:

"These fish had never been fed and because of its flat bottom the special pail carries such fish better than the regulation can. Vessels having flat bottoms are better for holding the fry of salmon, Loch Leven trout and other very small fish that are inclined to huddle on the bottoms of hatchery troughs and transportation equipment."

8. One thousand 1-inch brook trout produced at the Duluth hatchery were placed in a pail at 7:00 a. m., June 6. The train left Duluth at 8:00 a. m. With the exception of pouring the fish into the pail there was no aeration other than that furnished by the motion of the train until the fish were delivered to an applicant at 1:30 a. m., in good condition. The following is an exact from a letter received from one of the captains who tested these pails on his car:

"The ice tray of the pail is very desirable as it allows the aerating hose to go through the central opening, enables observation of the fish and has a tendency to keep the fish from jumping when the compartment cover is lifted, admitting bright light unexpectedly to the upper tier.

"The upper and lower tier means that one can is placed upon another thus carrying 6 lots of fish in the same space where 3 lots are now carried on the car in the fish compartment. This will double the capacity of the present cars."

9. The following has reference to a shipment of 4,000 brook trout No. 2 fingerlings produced at the Manchester, Iowa, station and shipped from Rhinelander, Wisconsin, to Pembine, Wisconsin, on May 26th. The fish were placed in 5 pails of the new type. The consignment left Rhinelander without an attendant at 5:00 a. m., due to arrive at Pembine at 11:45 a. m. The following is a communication received from Mr. E. G. Sauld, Secretary of the Pembine Gun Club, in regard to this shipment:

"The fish arrived on schedule time and were in good condition. We spent the balance of the afternoon in putting them in the small stream."

10. The following extract from the Fisheries Service Bulletin of July, 1922, reflects the attitude of the Bureau with reference to the pail as a means for carrying fish on cars:

"A further experiment in the use of the new type of fish transportation can, mentioned in previous issues of the Bulletin, tends to further demonstrate its value in effecting greater economy in the Bureau's distribution work. It has been demonstrated that by substituting the new type of can the carrying capacity of the distribution cars may be increased approximately 66 2-3 per cent with the present arrangement of space. Since this can successfully carries the same number of fish with practically one-half the amount of water, the weight of the load of the car is not increased and no extra work to the attendant is entailed. A sufficient number of cans to equip one of the Bureau's cars are now being made for the Bureau at the Naval Gun Factory, Washington, D. C., Navy Yard. Should the further use of the cans continue to produce as satisfactory results as have thus far been experienced, it will be possible with slight alterations to the interior arrangement of the fish compartments to double the carrying capacity of the transportation cars."

COMMERCIAL VALUE.

From the experiments conducted it is believed that the device can be used for shipping fish to market alive. Automatic aeration seems to work admirably in connection with large fish, especially trout and bass. As the experiments have been conducted along conservative lines, the maximum capacity of the pail for adult fishes has not been demonstrated. On the Edenton, North Carolina, shipment previously mentioned, ten pounds of bass were carried in 4 gallons of water. The writer does not question the possibility of shipping live trout from western Pennsylvania to Philadelphia, Washington and New York in pails of this type. The device is not limited as to size or shape and the underlying principles may be applied to large tanks or cars as readily as to smaller vessels.

The goldfish shipper will find the pail of especial value in marketing his product. The American Railway Express Company is interested in a suitable container for shipping goldfish, as the company is held responsible for the numerous losses of fish forwarded by express in the various types of cans. Since the express company is willing to ice fish and add water from time to time, there seems to be no reason why goldfish could not be shipped safely great distances with the minnow-bucket type of pail containing the evaporation jacket and automatic siphon.

That fish can be shipped considerable distances without an attendant has been fully demonstrated. Of the hundreds of shipments forwarded by express and baggage last year no instance is recorded where delivery was not as satisfactorily made as if the fish had been accompanied by an attendant.

MINNOW BUCKET TYPE.

This type of bucket is made with an air space at the top of the tray so shaped that it will facilitate pouring the fish from the tray, the cover being provided with a hinged lid. This device may be secured to a boat or other convenient object by means of a cord attached to a ring. Furthermore, it may be placed within the outer receptacle and will then perform the functions of the bottom tray heretofore described in addition to its function as a floating pail.

There is a demand on the part of anglers for a minnow or bait bucket that will hold an ample supply of bait for a week-end's

fishing and one that will carry fish without bruising them. For this purpose the pail will be a valuable adjunct to the fisherman's equipment whether the transportation to the fishing grounds be by rail or automobile. If by rail the pail will be placed in the baggage car while the angler enjoys the comforts of a Pullman.

CONCLUSION.

The outlook for the successful application of the underlying principles of the device to the distribution work of the U. S. Government, the States, goldfish shippers, and private fish culturists is very promising indeed. By placing 5 pails in the space occupied by three milk cans the carrying capacity of the Bureau's cars has been increased 66 2/3 per cent. By installing light, movable trays it will, it is believed, be possible to increase the load 100 per cent, and in specially built cars as many as three tiers of pails could be carried. This radical change in the methods of handling live fish will permit the concentration of the fish propagation work at points where conditions are ideal for fish culture, as the problem of distributing the product will not be as serious as it is with present equipment. It is also fair to assume that in the course of years the automobile truck will be used more extensively for making deliveries of fish. The pail is light, it rides smoothly, and a three-ton truck could easily be equipped with racks that would permit it to carry as many fish as have been carried by one of the specially-equipped distribution cars.

The use of a bail on a fish container facilitates handling and enables expeditious deliveries of fish while the train makes its usual stop. The pails may be double-decked on the car platform in anticipation of the delivery, and the transfer of fish made in the minimum amount of time. This saving of time is of great importance at railroad stations, where 30 or 40 cans of fish are to be delivered to applicants.

In handling fish in milk cans it has been noticeable that baggagemen frequently permit the can practically to fall from the door of the car to the pavement, the men handling the can merely serving to guide it in its downward course. This condition prevails to some extent at stations and on cars, and it is reasonable to assume that the shock which the fish receive produces in many instances unfavorable results. It is believed that the primary reason for rough handling, excessive weight, will have been elimi-

nated when the pail comes into general use.

In shipping fish it is not enough merely to make delivery of the consignment in what is usually termed "good condition." A satisfied applicant does not always indicate that the fish were in first-class condition at the time of their receipt. Improper handling at the station or in transit may result in fatalities days, and even weeks, after the fish have been planted. The success of fish culture will be measured in the final analysis by the number of fish that survive and reproduce after being planted. With this in view it is of the utmost importance that the matter of fish transportation and fish planting be given due consideration.

The writer does not contend that the pail is mechanically perfect, or that its full possibilities have been thoroughly demonstrated. The experiments have, it is believed, been carried far enough to satisfy most fish-culturists that an important step has been taken in the art of transporting live fish.

Briefly, the advantages of this container over the old type may be summarized as follows:

1. It permits the carrying of fish in one-half the amount of water commonly used.

2. It aerates all water in the can when the receptacle is in motion, the slightest agitation producing aeration.

3. It aerates without splashing and rides smoothly over the roughest roads.

4. The fish are held in the purest water of the can, near the surface where the oxygen is readily absorbed.

5. The fish being carried in a supplemental compartment are not disturbed by the wave motion as is the case in ordinary receptacles. The aerated water is jetted into this compartment, creating an artificial water level therein, which causes a current through the bottom apertures, removing all pollution from the tray to the bottom of the outside container.

6. When the vessel is not agitated, the fish are left in shallow water and their swimming efforts utilized to produce aeration.

7. It permits the shipment of fish for considerable distances without the usual attendant.

8. It maintains an equable temperature. Means are provided for automatically moistening the absorbent covering of the outer receptacle. The evaporation of moisture on this cover absorbs

the atmospheric heat and reduces the water temperature sufficiently to permit the carrying of warm-water fishes, even in low altitudes, during the warmest weather.

9. The pail is provided with a compartment for carrying ice in the event that trout are handled during the warm summer months.

10. The lid of the minnow bucket is so shaped that it does not permit the dripping of ice water on the fish, but feeds the water from the melting ice into the fish compartment indirectly, making the change of temperature very gradual.

11. It automatically siphons pollution from the bottom of the container when new water is added, maintaining a fixed water level.

12. The tray of the minnow bucket type is made with a float and may be used as a live car.

13. The parts are made so that they will nest, requiring a minimum amount of space in shipment from the hatchery or on return trips.

14. Air vents are provided in the sides of the outside container and packages placed on the top of the pail do not exclude the air from the fish.

15. It is easier to handle, as one man can carry two pails whereas two men are required to handle one 10-gallon can.

16. It is useful in the transportation of fish eggs.

17. The tray fits the standard hatchery trough and fish may be counted at an opportune time well in advance of shipment and held until required.

18. It affords a safe and practical means of transporting fish to the headwaters of streams which have heretofore been neglected on account of their inaccessibility.

There are many factors that must be taken into consideration in carrying live fish. It is not the intention that the device be used with tray when carrying fry. Neither should it be understood that the utilization of the swimming efforts of fishes can be advantageously applied to all sizes of fish. The method provides for holding fish in sanitary condition near the surface of the water, jetting the water into the compartment when the receptacle is in motion and utilizing the swimming efforts in emergencies only.

It may be stated that a large saving in last year's distribution allotment was effected by the use of the device described in this

paper, notwithstanding that distribution work was exceedingly heavy.

Discussion.

MR. J. N. COBB, Seattle, Wash.: Have there been any cans of that type developed by other people? If so, just what are the original features of your can as compared with theirs?

MR. FEARNOW: The 18 points summarized in my article show the advantages of this device over other types of fish containers. The combination of a canvas jacket and receptacle, with a means having ventilating and water aerating apertures for retaining a cooling medium, is new. The canvas jacket alone is not new. Of course, the idea of absorbing atmospheric heat through evaporation has been known virtually for ages, particularly in the Far East. I do not believe that the canvas jacket has ever been used before to lower the water temperature in the transportation of live fish.

Another feature is the automatic syphon, in combination, of course, with a fish container. A feature I consider entirely new is the aerating pan, designed to hold the fish near the surface of the water. I do not mean to say there have not been compartments for minnow buckets, but there has been no compartment that embraces the fundamental idea of this container. The substantially imperforate bottom of this compartment restricts the movement of the water and directs its force to the upper apertures. The idea is to hold the fish in comparative stillness in this compartment and to jet the water into it.

MR. J. W. TITCOMB, Hartford, Conn.: Well, Mr. Fearnow, as a member of this committee I want you to feel that we realize the importance of this device, and if it receives a prize it means that perhaps thousands of dollars will be invested in it by commissions who want to try it. How far is the device submitted this year different from the presentation of last year?

MR. FEARNOW: This device includes last year's device, with added features. If you remove the automatic siphon, place handles on this container, leave the tray out of consideration, and place a different type of lid on it, you have last year's device, which was a shallow water container with a canvas jacket.

MR. TITCOMB: It is well recognized that the shallow water method of transporting fish has been used by the Japanese for ages. You consider, of course, that yours is an improvement over that. If the container is standing still for two or three hours with fingerling trout in it, you think they are going to move around sufficiently to aerate themselves.

MR. FEARNOW: The Japanese method is based almost entirely on spontaneous aeration. The fish are carried in shallow water in tubs. No provision is made for lowering the temperature, removing sediment, aerating the water without disturbing the fish, or utilizing the swimming efforts of he fish to assist in aeration. The practical value of my device, as far as automatic aerating is concerned, is in connection with the larger sized fishes,

especially trout and bass.

MR. TITCOMB: Where the can sets out on a warm day for several hours, say at a junction point, how do you depend on keeping it iced?

MR. FEARNOW: We depend on keeping warm-water fish cool by the absorption of atmospheric heat through evaporation. The jacket has a flap that draws the moisture from the can. Besides, if the jacket were thoroughly saturated and the can taken off the train at a junction point, it would retain that moisture for a reasonable length of time. A shipment of trout could be made for a reasonable distance, for 8 or possibly 10 hours, in hot weather, by moistening the jacket and drawing the flap over as a protection to the ice. The melting ice also assists in keeping the jacket moist. A shipment of trout arrived at Central Station from White Sulphur Springs, West Virginia, a few days before I left Washington. There were about 25 3½-inch fish in the can and they arrived in excellent condition. So far we have not had what could be considered a failure, a real loss of fish, in using this device.

MR. F. E. HARE, Manchester, Iowa: How about the young fry?

MR. FEARNOW: The idea is to carry the fry and up to fingerlings No. 2 size in the can without the compartment. In that case the problem of aeration is insignificant. The upper tray serves as an ice container. It also provides aeration because any water that happens to slop up through these perforations will trickle back. In carrying fry the water should be up to the siphon port; that is the normal water level. As to 4-inch fingerling brook trout, in hot weather I would not attempt to carry over 75, as in a 10-gallon can. Two of the Bureau's car captains who have tried the pails have asked for full equipment of their cars.

MR. TITCOMB: You quoted the Bureau of Fisheries Service Bulletin as commending this method of transportation. In the closing part, it states that if the test of the 65 cans you made continues to prove satisfactory, all of the cars will be equipped. Have you reached the point where you would say that the test was so satisfactory that the cars were to be equipped?

MR. FEARNOW: We could have probably a thousand of these cans in service now had I not wanted it subjected to every possible test.

MR. TITCOMB: This other pail is really a minnow pail, is it not?

MR. FEARNOW: It is valuable for carrying fingerling fish and adults, but it does not seem to meet our special requirements quite so well as this one. I make every claim for the minnow bucket feature that was made for the other, with the exception that it cannot be used without the intermediate compartment. It is not used on the cars. It would be valuable for collecting fish at stations, or for use on messenger shipments.

MR. TITCOMB: What entirely novel feature is there in the combination tray or lid?

MR. FEARNOW: It is the process of aeration—jetting the water into the compartment. It is really a combination of two trays provided with a float.

MR. CHARLES O. HAYFORD, Hackettstown, N. J.: This device is very interesting to me, for in our State we handle practically all our distribution

by truck. We do not make more than half a dozen train shipments in a year, and it looks to me as if we might almost double the amount of fish we are putting out if this system can be successfully employed. I say that for this reason; a man with a Ford car could take a number of these pails and distribute the fish thinly along the streams. The average man who takes out the fish wants to get rid of them as soon as possible once he gets to his destination. I would rather have one can of fish planted properly—thinly scattered along the stream, among the stumps and at other desirable points—than ten cans dumped indiscriminately.

Mr. Titcomb: I tried the canvas jacket a good many years ago, and it was only the expense that kept us from adopting it. In some states a 5-gallon can is being used in place of a 10-gallon can, for the reason that a man can so easily take two 5-gallon cans in his hands. They are popular in the hatchery on that account; and of course they have the same feature that Mr. Hayford speaks about—the advantage in planting. But if we can get a combination—Mr. Fearnow's idea—which has all these advantages and others as well, we have made a distinct step in advance.

Mr. Fearnow: Probably Mr. Titcomb has reference to the padded covers used on fish cans at some of the New England hatcheries years ago, which was simply a method of insulation. I believe I am safe in saying that a receptacle with an absorbent jacket provided with a flap for retaining a cooling medium and means for moistening the jacket is something new.

Mr. G. C. Leach, Washington, D. C.: Do you believe that both diameter and depth in a container count?

Mr. Titcomb: I certainly do. I would be inclined to make these pails two inches greater in diameter. I am a great believer in shallow water, not over 8 or 10 inches in depth.

Mr. C. F. Culler, Homer, Minn.: How does the old Atkins can differ from this one? Would you say the Atkins can would not carry fish as well as this?

Mr. Fearnow: The Atkins can is simply a shallow water container 17½ inches in diameter with a narrow neck. It is not provided with means for controlling the temperature, removing sediment, or facilitating aeration. The can is awkward to handle and as a practical and economical method of distributing fish it is considered a failure.

Mr. H. L. Canfield, Homer, Minn.: In transporting fish in eight or ten inches of water does not Mr. Titcomb think some difficulty would be experienced in going over rough roads or pavements; would not the splashing of the water injure the fish. On a trip from Jersey City to the Battery, New York, 30 or 40 adult landlocked salmon were transported by truck in a square tank holding about fifty gallons. When the messenger left the car they were in pretty good condition, but the bumping splashed the water about and threw the fish against the sides of the can. The water was gradually reduced, and upon arrival only one-third or one-quarter of it remained, and all but a very few of the fish were dead. You could not carry as many fish in 8 or 10 inches of water, using the plain bucket, as

you could if you had more water; that is, if the pail was filled to within a couple of inches of the top.

MR. TITCOMB: I suppose the object of this pail is to overcome the very difficulties you mention—of the water slopping and leaving the fish high and dry.

MR. CANFIELD: I was speaking of the matter in a general way. The point I wished to bring out was whether or not it is the generally accepted idea that it is a good plan in all cases to use very shallow water in transporting fish. I think there would be a great many instances where it would be detrimental to do so.

MR. TITCOMB: There might be cases where it would be detrimental. The Japanese bring their goldfish to this country, all the way from Japan, in trays that have about 2 inches of water. The idea of shallow water is to give the fish more air; so that if you can get a container that will carry them in shallow water and not have it all slopped out when going over rough roads, you have something well worth while. Of course you realize that the landlocked salmon is one of the most difficult fish to carry.

MR. HARE: In carrying fry I find that you get an ideal can by using that large tray inverted. It is a wonderful improvement over the ordinary method.

MR. FEARNOW: I see something new in this can every day. One of our men was speaking of a method of combining the trays in such a way that you could place them in a stream at night; when making shipment you could pour fish into the container and place the large tray on top, inverted.

MR. TITCOMB: I consider our 10-gallon round-shouldered can the worst device ever invented. It is too heavy to carry and almost impossible for getting fish into spring rivulets and the headwaters of a stream. I urge my applicants to use lighter receptacles in the final transfer of the fish. I am almost inclined to order light tin cans, even if we smash them up in one season; I think we would in the end get more fish planted and get better results generally than by using the heavy cans.

I like the straight pail. I like the idea here; if we can prove that Mr. Fearnow's device has all the advantages claimed for it, I am ready to order all we need for our work. I know from tests I have already made that we could carry twice as many fish as we carry now with the round-shouldered cans. We ship entirely by truck in Connecticut.

MR. LEACH: The Bureau of Fisheries has made a number of experiments with these pails and is planning to purchase a larger number with the view of determining their value in comparison with present equipment. From experience gained by tests made at the Bureau it has been found that the larger fish, from 4 inches and upward, assist in aerating the water by their movements in this upper tray. I have found that the pail will do everything that the 10-gallon can will do, and a little bit more. I figure that a 10-gallon can will carry 100 3-inch fish; this can will do the same thing. One man can handle two of these cans; two men are required to handle one of the 10-gallon cans. These are much easier to load. In the

handling of whitefish fry at Duluth and other stations it takes ten men to load nine cans of the round-shouldered type on the boat; ten men will load twenty of these pails.

I believe this bucket will revolutionize and cheapen the distribution of fish. It is a very easy matter to stack them in the car one on top of the other. In carrying them on an auto truck it is an easy matter to put one row of cans on the bottom of the truck, and with a little platform in between you can stack the other row on top. You will not then have a total height of much more than 20 or 30 inches, and the truck will not be top-heavy. In that way I believe a two or three-ton truck can carry 75 or 85 of these cans. Those of you who are interested in distributing fish by truck will find, I believe, that you can more than double your capacity.

Mr. E. W. Cobb, St. Paul, Minn.: In Minnesota we have along the north shore of Lake Superior a stretch of considerably over one hundred miles of good road running parallel with the shore, but there is no railroad. We have purchased a truck and plan to plant the fry ourselves. The road is well surfaced but not well graded; it is up and down hill all the way. I think that this will be an ideal place to try out some of these cans during the coming year. If they will stand that trip, they will stand any you may give them.

Mr. Fearnow: This can seems to carry fish remarkably well in automobiles. The Potomac Anglers' Club took a shipment of trout from Washington forty miles into Virginia over the worst roads possible. The president of the club later remarked particularly that it did not seem to splash as the ordinary ten-gallon can would. He told me that the bottom of his automobile was not wet when he reached his destination—the little slop had been taken up by the absorbent jacket. I have also carried fish a considerable distance over rough roads in Maryland.

Mr. Dwight Lydell, Comstock Park, Mich.: I want to get hold of half a dozen of these cans to enable a thorough trial, and if they do the work I think that a considerable number will be ordered by the Conservation Department of Michigan.

THE PLANKTON OF THE LAKES.

By E. A. Birge

President, University of Wisconsin, Madison, Wis.

I shall speak this morning about the plankton of inland lakes—that assemblage of minute plants and animals which float in the open waters of the lake and which constitute a great part of the fundamental food for all higher aquatic organisms. The Wisconsin Geological and Natural History Survey has for years devoted much attention to the investigation of this complex subject, and I have here an early copy of a report which covers a part of that work. It deals with the quantity and the chemical composition of the plankton of Lake Mendota and adjacent lakes.

As the older members of this Society know, I have been much interested in the study of limnology and for a good many years I took an active part in it. In recent years I have had other duties and most of the work for our reports has been done by Mr. C. Juday, who has given all of his time to it since 1905. I had expected him to do much of the talking today, but he is necessarily absent from the city. I am very sorry that you should lose the advantage of his great knowledge of the subject.

The field work for this report was carried on from 1911 to 1917, and was executed upon a large scale. We secured the plankton from large quantities of water in such amounts that chemical analyses could be made. Food analyses were also made so that some notion could be reached not only of the quantity of the plankton but also of its value as food. All of these results are summarized in this report, which is very definitely scientific in character, and is for reference rather than for general reading. [1]

A very good and more popular account may be found in the report of the New York Conservation Commission on Lake George. This gives an excellent general account of the plankton and its relation to the fish besides much other information on the lake. [2]

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[1] The Inland Lakes of Wisconsin. The Plankton: Its Quantity and Chemical Composition. E. A. Birge and C. Juday. 1922.

[2] A Biological Survey of Lake George. J. G. Needham, C. Juday, E. Morse, C. K. Sibley and J. W. Titcomb. 1922.

For practical purposes the plankton may be divided into two groups, separated chiefly by the size of the organisms: (1) that which can be strained from the water by a net of fine silk bolting cloth, and (2) that whose individuals are so small that they must be extracted from the water by a centrifuge or similar divice.

To the first group belong all of the larger animals of the plankton, such as the water-fleas (Cladocera and Copepoda) which are of special interest to us here, because they constitute an important item in the food of the fish. It also includes the larger algæ—those, for instance, which give rise to the "green scum" in lakes—and the larger diatoms. The second group includes the very minute animals (protozoa) and algæ, together with the bacteria of the water.

In the investigation that I am reporting the Survey both strained and centrifuged large quantities of water, doing this work in a special laboratory on the shore of Lake Mendota. Altogether, in 481 catches made from 1911 to 1917, we strained out the plankton from about 4,750,000 pounds of water (2,157,000 liters), securing some 45 ounces (1,292 grams) of dry material for chemical and food analysis. The water centrifuged to secure the minuter organisms during the years 1915-1917 was necessarily much less in quantity; but it aggregated in 184 catches about 482,000 pounds, from which we obtained somewhat less than 24 ounces (752 grams) of dry material, nearly half of which was fine silt derived from the water and less than half was organic material. These facts look as though the food material of the open water of the lakes is very small in amount, but it is really quite considerable. If the ash is taken out the average amount of dry organic material yielded by the plankton of Lake Mendota is about two pounds in a million pounds of water. In the living condition about nine-tenths of the weight of these plants and animals consist of water, so that in the lake there are by weight about 20 parts of live plankton to a million of water.

This quantity in the area occupied by the deeper water of Lake Mendota (depth 20 m. or more) would give a standing crop of more than 3,800 pounds per acre, or nearly two tons of fresh material. February yielded the smallest amount—about 2,300 pounds per acre—and December the largest—about 4,500

pounds per acre. The larger planktonts, those caught by the net, consitute only a small part of this total in most lakes and at most seasons. In Lake Mendota the net plankton never quite equalled that extracted by the centrifuge, and at the maximum the centrifuge yielded nearly 25 times as much as the net. On the average there was about five times as much plankton from centrifuge as from net. Thus the more minute organisms, those which have the shortest life and the most rapid reproduction, constitute by far the larger part of the standing crop; and this is of great significance in estimating the annual turnover. In other lakes the net has yielded an even smaller proportion of the total plankton. In Lake George (164 feet deep) and in Green Lake (237 feet deep) it has been found in mid-summer so low as one-fortieth of the total.

These studies on large quantities of water have been made on Lake Mendota and the two neighboring lakes which can be reached by a launch. These lakes range in maximum depth from 11 meters to 24 meters. During last year and the present season we have been carrying on our studies with smaller and portable apparatus in Green Lake which reaches a depth of 65 meters. We find that in all of these lakes the quantity of plankton per unit of area of the deeper water of the lake is not widely different, no matter what the depth of the water may be. Of course, it varies a good deal with years and with season, but, after all, in any of these lakes it is of the same order of magnitude, say about two tons of live plankton per acre of deep water. It is yet doubtful whether this will be found true of the far deeper lakes like the Finger Lakes of New York, and I do not see but that the very deep lakes ought to give a larger amount. But still it seems a fair provisional conclusion from our studies, that the fundamental capacity for production in a lake depends on area and not on depth. While there are plants which might and probably do multiply as saprophytes in the deeper water, they do not seem to add appreciably to the crop of plankton and the bacteria are a very insignificant part of the standing crop. Other things being equal, the production of food in the open water is a function of surface, not one of depth.

This statement might seem to be a necessary result of the fact that plants depend on sunlight for the manufacture of organic matter. But it is really unexpected and the reasons for

it are still to seek. For there is a far greater amount of organic substance dissolved in the water of a lake than is contained in the living organisms. There may be four or five times as much, and the sum may rise as high as ten times. We do not know why plants that are not green and can not manufacture organic substances with the aid of the sun, do not utilize this material and develop in large numbers. This indeed they sometimes do and growths of plants like Oscillatoria may occasionally be found in the deeper water of lakes, evidently supported by these dissolved substances. But such growths are rare and so far as our experience goes they contribute little to the general food supply.

The same may be said of bacteria. These are always present in the water and often in large numbers. Our studies show that there was an average of about 30,000 bacteria per cubic centimeter of water during the summer of 1920, while the average for 1919 was only about 3,000. But the quantity of organic matter yielded by these numbers is small. Even 30,000 bacteria per cubic centimeter at the average size of those in Lake Mendota would weigh less than one-six hundredth part of the weight of the other plankton organisms, and the weight of bacteria in 1919 averaged only one-tenth as much as in 1920. We are still quite ignorant of the agencies that limit the number of bacteria.

Thus the fundamental food supply of the open water comes back to the algæ and to the creatures that feed upon them. And we must conclude that the total amount of this supply of food is mainly a function of the surface of the lake and not of its depth. Depth dilutes the food supply but does not add to it, and if this is true, then the total amount of living material in the form of fish that can be supported by an acre of open water is rather decreased than increased by addition to the depth of water.

In this assemblage of plankton plants and animals one group is of especial interest to us—that of the entomostraca, or water-fleas—which convert the algæ into a form available as food for fish. These little crustacea—Cyclops, Diaptomus, Daphnia, and their relatives—constitute one of the most important sources of fish food.

There is a second similar group in the plankton, that of the rotifers. But these "wheel animalcules" are small individually and they are rarely present in numbers sufficient to make a sub-

stantial addition to the menu. The entomostraca which eat the algæ directly in the open water and the insect larvæ which feed on them as they die and sink to the bottom, constitute the main direct contribution of the open lake to the food of the fish. There are fish, like the gizzard shad, which feed directly on algæ, but such fish are few and most fish get their food in form of animals. We are therefore much concerned with those creatures which serve as intermediaries between algæ and fish.

We have been able to make rough determinations of the quantity of entomostraca in the plankton. In Lake Mendota the eaters in the plankton—crustacea and rotifers—make on an average about one-eighteenth of the total plankton. Such an average is, of course, subject to wide variation, as both animals and plants come on in waves; but it is rarely the case that the eaters find in the water less than a dozen times their weight of food. This seems a liberal provision. If a "beef critter," for instance, weighing 1,000 pounds had a constantly renewed stock of green food amounting to 10,000 pounds or 20,000 pounds, he would seem to be amply supplied. But the algæ are not concentrated into a sort of sheet or carpet like the grass; the animal must strain them or pick them out of the water. No fresh water animal has a better straining apparatus than has Daphnia, but when I tell you that in Lake Mendota a Daphnia must extract the algæ from 60,000 times her own weight of water in order to obtain her own weight of food you will see that life for her involves no small amount of work.

The same statement may be made of other plankton animals. In lakes like Green Lake, the quantity of plankton is smaller and the crustacea are in general smaller and fewer per unit of volume of water. The animals of the plankton seem everywhere to be as great in quantity as the plants will support.

In general the same statement may be made of the weight of crustacea per unit of area of a lake, that was made of the total plankton. In lakes of very various depths the number of pounds per acre is not widely different, and the deep lake has no observable advantage over the shallower one. In the deeper water (20-24 m.) of Lake Mendota the plankton crustacea and rotifers may yield a standing crop of something over 20 pounds of dry organic material per acre, or over 200 pounds of fresh meat, "on the hoof," as it were. This average is subject to much varia-

tion, as yet not exactly determined. The crop doubtless falls as low as 10 pounds per acre at some seasons and rises in spring as high as 50 pounds or even higher.

In other lakes we have found the crop as small as 7 pounds of dry matter per acre in Canandaigua Lake (150 ft. deep); about 10 pounds in Cayuga Lake (450 ft.); 24 pounds in Seneca Lake (600 ft.); and nearly 30 pounds in Green Lake (237 ft.) These were single observations and I have no doubt that the amount found in any one of these lakes could have been found in any other of them on a different occasion.

Such a crop of, say, 200 pounds of live crustacea per acre, seems small, but even so the annual production is great. In Lake Mendota Daphnia produces some three broods per month during the spring. If we estimated the turnover at only twice a month (and such an estimate is doubtless too low) during the period from May 15 to September 15, there would be eight crops during the period and a production of 1,600 pounds of animal food per acre. This is, of course, far in excess of the production of animal food from an acre of land, and the period of production includes spring and fall also, and even winter for some forms.

Thus if we look at the lake as an enterprise for converting algæ into potential food for fish we must agree that it is by no means inefficient. Little as we know of the details of the processes, the gross results as we see them today are very creditable. How far the fish are able to utilize this potential food is quite another question, and one of whose answer we are quite ignorant. So far as I am aware, no one has made a study of the subject.

Here, then, are a few words on one great branch of the story of the plankton of lakes so far as it directly interests us of the American Fisheries Society. We must think of a plant population numbering millions and often billions of individuals in a cubic meter of water—most of them so small that they add no observable turbidity to the water as seen in a glass vessel, yet present in such numbers as to yield a standing crop of nearly two tons per acre in a moderately deep lake. This standing crop is constantly renewed as its shortlived members reproduce and die. It supplies food which maintains a standing crop of animal life in its higher forms, though still minute, which amounts to 200 pounds per acre, more or less; or, say, perhaps one-twentieth of the weight of the plants on which it feeds. And out of this

animal life there may come an annual supply of potential food for fish which we can not estimate at less than 1,500 pounds per acre and which is probably much larger. How far the fish use this supply is a question to be determined by you who raise them.

I mentioned the insect larvæ, and while these do not belong to the plankton I must say something about them, or at least about those insect larvæ which live on the bottom of the open lake in the deeper water. You are all familiar with these larvæ, may-flies, bloodworms (Chironomus), phantom larvæ (Corethra) and many others. These constitute a second and smaller stream of animal life that issues from the vegetable plankton, aided by that part of the shore plants which sinks to the bottom of the deep water. For as the planktonts die they gradually sink in a sort of gentle rain to the bottom and there they accumulate in an ooze which supplies nutrition to these larvæ and as well to worms, to clams, and to crustacea. All of these animals furnish food to bottom feeding fishes and the quantity of animal matter thus maintained is often very considerable. In the depths of Green Lake there lives a crustacean—Pontoporeia—a relative of the scud or "shrimp" familiar in every fish hatchery pond. We have found this animal in quantities as large as 74 pounds dry weight per acre, over large areas of the bottom. This is much larger than the standing crop of the plankton crustacea, but reproduction is much slower and the annual crop is therefore smaller. Lake Mendota has no Pontoporeia but has almost innumerable insect larvæ, chiefly midge larvæ—Chironomus—and especially Corethra. There are also many worms and small clams (Pisidium). The total annual crop from all of these may aggregate some 112 pounds of dry organic matter per acre in the deep water, an amount which is much less than the annual crop from the open water itself.

In order to give you some visible idea of the amount and distribution of the plankton I have made a diagram showing a set of observations made this summer on Green Lake, Wisconsin. On the right side you will see the temperature indicated. There are some ten meters of warm water on top; then comes the thermocline, five meters thick, in which the temperature falls from 21° C. to 9° C. (70° to 48° F.). Then follows a very slow fall of temperature through the cold water to the bottom, reaching 4.7° C. (about 40° F.) at a depth of 65 m. (about 215 ft.). The

numbers on the left side of the diagram indicate the depth in meters. The figures at the top indicate the dry weight of the organic matter of the plankton in milligrams per cubic meter of water. The live weight is about ten times as great. The total quantity of fresh plankton in a column of water one meter square and 65 m. high is about 455 grams, a little over 16 ounces.

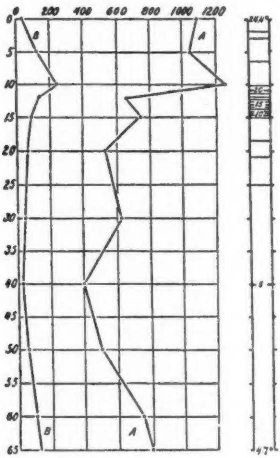

Diagram showing temperature of Green Lake, Wis., and quantity of organic matter in its plankton on Aug. 17, 1922. Temperature in centigrade degrees; depth in meters; weight of plankton in milligrams of dry organic matter per cubic meter of water.

A—A, total plankton; B—B, net plankton. For explanation see text.

The two lines, A-A and B-B, indicate the dry organic matter of the plankton at the various depths; B-B shows the larger planktonts collected by the net to which A-A adds the material extracted by the centrifuge and therefore shows the total planktons. You will see that the smaller creatures constitute by far the greater part of the total. It is also noteworthy that the quantity of plankton is greatest in the warm surface stratum, that it diminishes rapidly in the thermocline stratum of temperature and then decreases slowly, reaching a minimum at about 40 m. and increasing again toward the bottom.

This is a typical picture of the summer plankton of Green Lake. It represents a total of nearly 4,000 pounds of fresh material per acre of water at the depth indicated, of which the net

plankton constitutes about one-tenth. Probably more than half of the net plankton consists of animals, chiefly crustacea.

(Dr. Birge had brought with him the portable centrifuge mentioned in his address and at the close he extracted the plankton from a pint or more of water from Lake Mendota. This water was perfectly clear to the eye, but there collected in the bowl of the centrifuge a considerable quantity of minute organisms which adhered to the wall of the bowl. These were chiefly algæ belonging to the genus Aphanocapsa, the dominant form in the centrifuge plankton of most lakes).

Discussion.

MR. J. W. TITCOMB, Hartford, Conn.: May I ask Dr. Birge whether he gets the same results in his winter observations?

DR. BIRGE: In general, yes, but you cannot make plankton observations in the winter with the same regularity as in the summer. During the open season we expect to make two observations a week on Lake Mendota, but during the winter may go out only four or five times altogether. In one year the maximum amount of plankton was in December; it ran down during the winter, and then in March it began rising again slowly. It went up very rapidly in April, then fell off in the summer and rose again in the fall. The number of crustacea in Lake Mendota, the lake which we know most about, is greatest in April, May and early June. I have always had the notion—I give it for what it is worth—that in the lakes these water fleas "get the jump" on the fishes in the spring; they start out earlier than the fish, and then the little fishes come on and run them down. That is my thought so far as Lake Mendota is concerned, but the question would have to be worked out on a good many lakes before we could speak very definitely. I do not know that this sequence of forms has been worked out quantitatively in streams.

MR. TITCOMB: You have in a scientific way explained why the shallow lake is more productive than the very deep lake. But the point not quite clear to me is about the relations of the higher forms of plants. The plankton and the algæ are intermixed, are they not?

DR. BIRGE: The algæ are part of the plankton.

MR. TITCOMB: What is the relation of the higher forms of plants to all these valuable plants that we think so much of here? Do they properly enter into the discussion?

DR. BIRGE: A few years ago we published a very elaborate paper on the shore plants, the insects, etc., that live in Lake Mendota. So we have a report on that subject, but we are still very far from knowing much about it. We have just completed also reports on water weeds—showing the amount of these plants per acre in Lake Mendota; we also worked them up in Green Lake, but the report is not yet published. It can be said that in the most productive parts of the edge of the lake about as much green stuff will grow per acre as will grow upon a meadow.

The only connection I brought in between these plants and the animals of the open water is the fact that as these plants die parts of them break

up in the water and contribute to the organic material at the botom of the lake, on which the insect larvæ like the Mayfly larvæ and the bloodworms, may feed.

Mr. Titcomb: Do you not think that most fishes like to live on the bottom? In a deep water lake it is not customary to find any of the various species feeding on the surface over the deep areas; they are in comparatively shallow water. This means that all this food, this great abundance of food in the plankton, is wasted.

Dr. Birge: A great amount of it must go to waste. Yet Green Lake has many small fish that go out in the deepest water. On a calm day your boat may be surrounded by hundreds of them. I refer particularly to one of the shiners, *Notropis atherinoides*. The young of this species is very abundant in the open water.

Mr. Titcomb: In connection with the Lake George survey, one of the interesting things we found there was that the small form of whitefish which inhabits that lake, and which is the main food of the lake trout when they are young, apparently comes to the surface at night to feed. They come to the surface just at dusk, when it is cool; you can see large schools of them on or near the surface. I suppose they come up for this food you speak of?

Dr. Birge: Probably. A great many of the deep water fish come to the surface at night. But the habits of both the fish and the water fleas vary greatly. You must bear in mind that there are scores of species of water fleas. For instance there is Daphnia pulex—a big, heavy-bodied water flea. That is the type you find in ponds; it is not found as abundantly in the open water of the lakes, and if present there it is found ordinarily in the deeper and colder water. In Lake Mendota it lives in the surface water during the winter and early spring, and as the temperature warms up it moves down from the surface; as the summer goes on the water at the bottom loses its oxygen and there are only a few feet of water that have a sufficient supply of oxygen to meet its needs. There are other delicate-bodied forms which are characteristic open water forms—they live in the open water of the lakes.

You will see that the study that I have reported relates chiefly to the food derived from the open waters of lakes and from the deep water as well. Its direct bearing on fish, therefore, is primarily with the fish of the open water, like whitefish, with the young of shore-living species, which may come out into the open water, and with the fish, which, like perch or white bass, are regularly shallow water forms, but which also come out into deep water for food. We have not studied these relations between fish and food; we have been determining the quantity of the food from the plankton and its general food value. Some of the commercially valuable fish of the Great Lakes, notably herring and whitefish, go back more directly to the plankton for food, than do the fish which most of you are raising.

If the Bureau of Fisheries could carry on such studies as ours in the Great Lakes the results might be more directly useful to the commercial fisheries than our studies on smaller lakes are to you. But we have been

studying one great source of food for fish in small lakes and therefore under conditions that are so limited in space as to permit such a study, we have done this in the hope of establishing principles and securing knowledge which will help all fisheries in the end.

MR. TITCOMB: Conceding that most of the little fishes keep away from the deeper water, it would appear that the main usefulness of these plankton organisms is at the bottom?

DR. BIRGE: If there is no appreciable number of small fish that are utilizing this material, then its main usefulness must be at the bottom. But I am not prepared to say that this is the case until the subject has been studied much more accurately than has hitherto been done. Our studies have been chiefly on the deeper water, but most of the fishes that this Society is directly concerned with are shore fishes, or shallow water species. Other forms of food may be more important to some of them than this plankton. Of course, the whitefish and lake trout, all the whitefish group, are open water fish. Has anyone ever tried to breed the young of the gizzard shad, *Dorosoma cepedianum*, as a food minnow? This fish, as you know, feeds on plankton algæ, and if it will multiply freely in lakes it might become a valuable foodfish, especially as it lives on material which very few fish can utilize. It seems to be more abundant in streams but is not absent from lakes.

DR. EMMELINE MOORE, Albany, N. Y.: In the early part of his remarks Dr. Birge referred to the source of the fishy odor as being mainly due to the crustaceans—Daphnias, Cyclops, and so on. Do you find that such flagellates as Synura and the Peridineæ, when they develop in very great numbers, are quite as much a source of that trouble?

DR. BIRGE: We have never found Synura in large numbers. It has been the same with Peridineæ—we find a few, but not enough to make any considerable part of the weight of the food. I should not doubt that these crustacea may get this fishy material out of oils in the vegetable food. I think that it is certain that they concentrate it; I will not say they manufacture it, though they may do this also. I was talking about the way the fish flavor got into the fish, and I think it does get in very largely through these crustacea, at least for fish that eat crustacea freely. I think they are feeding on these very fishy oils, and that that has something to do with their flavor.

MR. W. E. BARBER, LaCrosse, Wis.: In your research, Dr. Birge, have you determined why the perch in Lake Mendota run so small—why there are no large perch?

DR. BIRGE: No, I have not determined that, but if you want a guess I will give you one. In 1883 or 1884 there was an enormous mortality of the perch in Lake Mendota. They died by the million and their bodies were washed up along the shores; for years there was a windrow of bones all around the lake. Now, I can give you no statistics, but those perch that died were decidedly bigger than the perch that are now there. My theory has been this: the epidemic did not hit the little perch, and the death of the larger fish, which prey on the little ones gave these little fellows a fine

start. So instead of getting picked off they grew up in great numbers and became as big as they could. But they did not get food enough, and the result is that they are decidedly smaller than the perch which are found in lakes where there has been a natural depletion of the smaller fish from year to year. I was told by the former Commissioner of Fisheries of Pennsylvania that some of the men down there got hold of a small lake back in the mountains, stocked it with bass, and did nothing with it for some years. They thought they would go up there and see how the fish had been getting along. There were large numbers of bass in the lake, but while these had grown and were sexually mature, they were all small—I think not over four inches long. I imagine that if a dozen big bass were put in they would eat up many of these little fellows with the result that the fish would then be fewer, but larger.

Mr. Titcomb: The suggestion about these larger fish reducing the number of the smaller ones and perhaps changing the balance, is pertinent to another point. It is generally thought that the introduction of new blood in a lake does not improve the fish, that is, in a large, natural lake. I am wondering whether your theories there account for a change in the growth of fish in the waters I am going to mention, rather than the introduction of new blood. In this instance it was pickerel, *Esox reticulatus*. One pond stocked with fish never yielded anything over about twelve inches in length. The sportsmen went to a lake a few miles distant where the fish would run up to five pounds in weight, and imported some of these larger fish. Two years in succession they introduced the larger fish into this lake where the pickerel were of small growth and since then they have been catching large fish in those waters. Is that probably due to the fact that the large pickerel proceeded to restore the balance there and not to the introduction of new blood?

Dr. Birge: Yes, I think it is. You must bear this in mind: the supply of food in any lake from all sources is strictly limited, and you are getting at any given time, barring accidents, as much fish as the lake will raise—unless you increase the amount of food. The food all comes back to plankton material on the one hand and the shore material on the other. Now, you have no means of increasing the supply of food, so far as I know; and the question you have to solve is, can you get a better utilization? The question you raise would be a very interesting one to work out. Can you find a minnow, for example, which will swim out into the open water and eat this plankton more largely than it is now being eaten, and also allow itself to be eaten by other fish? If you can do that, there is no reason why you should not short-circuit some of these losses and turn them into useful flesh. I do not see that new blood of itself is going to make any appreciable difference in the matter; the fish in any lake are going to grow as big as they can on the food that is available to them.

Mr. M. D. Hart, Richmond, Va.: Would the selection of the best species as practised by agriculturists not have a tendency, in your opinion, to result in improvement so far as these various fishes are concerned?

Dr. Birge: There is no question that work of that kind could be done,

and that it would be very valuable indeed; but at the present there is no way of studying the problem since neither funds nor men are available. And the same is true of many other matters. Take this problem I have laid before you; none of you can say that it is a problem of major practical importance for today or tomorrow; but when you look upon fish culture as going on for a generation, then this sort of knowledge is absolutely essential. But here is a problem that only one man in the United States is working at; compare that with the manner in which the work at the agricultural experiment stations is carried on. Wisconsin is putting $5,000 a year into lake work, and that is more than all the other states are putting into this particular job. Money is going into agricultural experimentation and research by millions, whereas in the case of aquiculture it is coming in tens—and that is one reason why nobody can answer these questions that you raise.

You are bringing up here the question of fry vs. fingerlings. Thirty years ago, when I began coming to this Society, that question was up and it is just as fresh today. Why doesn't somebody get to work on it? Why doesn't somebody stock a stream for a number of years with fry; observe the results carefully; stock another stream with fingerlings; then change them about; find out whether fry or fingerlings are the best to plant and under what conditions? Well, it is because the money is not available to do it. There is not a State Fish Commission or a National Fish Commission anywhere that I know of that would take up a practical problem like that and work at it for years. Take what was said today of this Lake George report; why do we not know something about the young whitefish—about what it does from the time the egg is laid until the fish is mature; what it feeds on, where it lives, and so on? We are putting millions of dollars into such problems of the land; and we are right in doing so. But we do not study the problems of the water in the same way. When, a few years ago, they wanted a fish pathologist in Washington, Commissioner Smith wrote to me and asked that we help him to get $2,500 or $3,000 from Congress for that purpose. That is the way the fisheries business is being run—from hand to mouth. You have to beg for little driblets of money.

You are doing the best you can with the means you have; but through the nation and through the states there ought to be money for all sorts of investigations. There should be investigations going on that would continue for ten or fifteen years before final results were reached. Much of the work going on now at our agricultural experiment stations will proceed for years without direct results being noticeable; yet ultimately the results will revolutionize, perhaps, some important branch of agriculture. Certainly aquiculture should be handled in the same way.

ADJUSTMENT OF ENVIRONMENT vs. STOCKING—TO INCREASE THE PRODUCTIVITY OF FISH LIFE.

By Ernest Clive Brown

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The title for this article has been selected with a view to setting forth what I believe will be the underlying principles of the fish culture of the future, and though the topic as stated would seem to present an antithesis, it does not do so in fact, since each line of action supplements the other in endeavoring to attain maximum productivity of fish life.

While fish culture in artificial ponds was known to ancient China and to Egypt in the time of the Pharaohs, and in later times stood in high favor among the great landowners of the Roman Empire, relatively very little study has been made of the conditions of environment regulating the production of fishes in natural bodies of water. The oldest reliable records in aquatic biology date back only a little over half a century. Study and adjustment of aquatic environments to bring about conditions increasing the size and number of desirable fishes is therefore a relatively unexplored field.

Modern hatchery and rearing practices, achieved by the lifelong devotion of many earnest workers in and connected with federal, state, and private hatcheries, have greatly extended the quantity of young fishes returned to the waters over the number which could have been produced to the same stages by the parents under natural conditions. Still, I feel that fish culture as practiced today does not go far enough to meet the terrific attack which civilization is in part unwittingly making against the perpetuation of our native fishes and particularly our game fish. Let there be no doubt on this vital point. The weight of civilization is at present against the survival of our fishes.

Consider for a moment the opposing forces in the situation. They are too unequal for it to be called a struggle. On one side we find pollution killing our fishes; deforestation warming our trout brooks, if it does not alternately convert them to dry ravines and raging torrents; power storage project dams which prevent the ascent of anadromous fishes to their spawning grounds; irrigation projects which shunt the fishes from their native element

out upon the desert sands; and drainage of wet lands for agriculture which lowers the underlying water table of the surrounding country and exerts a harmful effect upon lakes perhaps miles distant in addition to absorbing a large part of the normal precipitation. The number of anglers is increasing with the population. As trout and other streams become uninhabitable to fishes the stream fishermen, urged on by the enormous amount of bass advertising run by the manufacturers of tackle, turn to join the multitude already on the lakes. As lakes and ponds become "fished out," polluted or are taken over by private individuals or protective associations, and the number available becomes less, concentration even upon the more distant waters is effected through the agency of the trolley, the automobile or the railroad. Once there, the outboard motor and the latest developments of tackle, which give surprising accuracy and speed in combing the waters, are brought into play, and baits which seldom miss a strike drag out the fish. In addition to all this—day and night, month after month, year after year—the great nets of the commercial fishermen reap their harvest. That is one side of the story.

On the other hand we find a native fish fauna whose reproductive capacities, even at their best during periods of favorable readjustment, are less than two per cent efficient under natural (undeveloped) conditions and have not increased one iota to withstand the tremendous devastation inflicted by the opposing forces. The fishes know no cooperation. Their entire lives are practically devoted to securing food without becoming it, and at the end nearly every one comes to a violent death in good health. Behind them, it is true, is solidly lined up every hatchery in the country turning out fry and fingerlings which have been carried through the period when they are subject to greatest mortality; hence so far as the body of water into which they are placed is concerned, this terrible loss is escaped. The hatcheries do not entirely overcome loss of young fish, but they do provide a concentrate of fry and a still greater concentrate of fingerlings for stocking which have survived owing to the care bestowed upon them. Hence, if one is to stock waters, the fingerlings used represent more efficiency at the time of planting than a like number produced naturally in the waters, the degree of efficiency achieved being the difference between the number of eggs required under natural conditions in the waters and the number required in the hatchery to produce

the same number of fingerlings. So far, good! But what becomes of these little fish when they are set free to sink or swim in our open waters? Does the average individual or fish and game association, to whom they must be entrusted, give them a good or even a fair chance for survival? It is regrettable, but I fear the answer must be negative.

Costly and disastrous mistakes on the part of individuals to whom fish are turned over for planting, or who secure them themselves from private hatcheries, are the rule rather than the exception. The usual haste which attends the actual introductions causes the fish to be literally dumped into waters at one or two convenient points without regard to equalizing the temperature in the cans or thought of possible shelter for the young fish while getting their bearings. Bass and pickerel are placed in waters ideal for trout. Trout are placed in natural bass waters. Trout and bass are placed in the same waters. Waters absolutely lacking in forage fish are heavily stocked with large, voracious, predatory species. Species which require running water on shallows for spawning are placed in deep lakes having no current, and vice versa. Large-mouth bass are placed in clear rock-bound lakes, while the small-mouth is introduced where mud and turbidity prevail. Fishes already nearly eliminated, either by other fishes of the natural succession or an environment to which they are unsuited, are given support by heavy stocking and the wasteful struggle is kept up for a few years longer. As if all the violent reactions which the foregoing lines of action create were not sufficient, much harm has been done by introduction of species for the sole reason that they were known favorably from other regions or even other countries. The carp and brown trout are notorious examples from abroad. Both are, indirectly and directly, respectively, highly destructive of our native fishes; neither furnish sport equal to that given by the indigenous species which they displace, and both, depending upon the individual case, are difficult if not impossible to eliminate. Thus it is seen that the almost incredible lack of knowledge which everywhere prevails among the average owners of waters, and to which may be added a deplorable lack of realization of the seriousness of the situation which our native fishes are facing, is probably the greatest single drawback to extension of our fish culture.

Intelligent stocking of waters requires more time and study than the average busy man can afford to give. The mere fact

that specimens of a non-indigenous species are seen a year or even two years after introduction does not prove that the species is established; for, while the individuals may exist for the periods of their life-times, the life cycle must be complete before the species can be considered established. That is, if the original introduction was made with yearlings, yearling fishes must be produced in the waters from their offspring before it is definitely shown that the species can exist therein. Misinterpretation of conditions such as this, based upon inadequate observation and experience—plus the difficulty of obtaining fish, particularly the warm water varieties for lakes and ponds, tends to concentrate the owner's attention to securing of fish alone. Haphazard plantings then prevail, and though natural results nearly always come about slowly, no definitely progressive policy is adhered to; and even though a wise plan may have been originally chosen, relapses occur which are fatal to success. Much money, effort and time are lost by misguided attempts to improve the situation, and after a number of years the fish life is probably less plentiful and the entire aquatic environment more unbalanced than before anything was attempted.

It has long been an axiom of mine that whatever condition exists tends to become intensified, and that in time cause becomes effect and effect cause. In other words, cause and effect become more and more inseparable; and the condition continues to develop at constantly accelerating speed unless it is met by other forces. Fortunately it would appear that the very nature of things has decreed that most situations have their compensation and a balance is established before serious collapse occurs due to overweight in any particular direction. The question now is—with a thorough understanding of the effect civilization is working upon our native fishes—can we apply the conpensating force?

It is my firm belief that the solution must be sought by study tending to extend our fish culture to include adjustment of aquatic environments. The advance which modern hatchery practices gain for the young fish must not end when they are planted. The years of experience behind the months of effort with the particular fish used in any given problem must not be vitiated by lack of understanding of the basic laws which control those fish after their liberation in open waters. Mere stocking is too frequently dealing with effects. Adjustment deals with causes. From now on we must

endeavor to master the riddles the solution of which will enable more fish to exist in a given area of a given type of water. As this is a very large subject, I merely wish to touch briefly upon certain salient points, which, if fixed in mind, will perhaps be of aid in future investigations.

In the accompanying Lake Table of Progressive Factors controlling the production of small-mouth bass under natural (undeveloped) conditions (Table I) I have endeavored to itemize the principal factors making up the environment in a lake where the fish cultural object is the maximum production of small-mouth black bass. The two groups are identical, but those at the top represent the dependent factors or those which are benefitted or otherwise influenced by the controlling or possibly limiting factors in the left hand column. All of the controlling factors directly influence various items in the other group as indicated by an X in the column beneath the item affected. The direct influence, as easily seen by consulting the table, is, however, little, if any, greater in importance than the indirect results which come about by multiplied action through the enormous number of reactions which make up an ecological environment. An attempt to diagram the influence of a single factor, such as turbidity, through the factors which it affects, then through those which they affect and so on and on, if only to the end of each cycle, will easily convince anyone as to the complexity of aquatic environments, and how impossible it is to disturb one element therein without bringing on readjustment almost throughout.

There can be no doubt that the rate of production of any species in lake, pond or stream is determined and regulated by the balance existing in the environment betwen those forces which are favorable to and those which are against increase. Therefore, if we can study and adjust the situation to extend and intensify the favorable factors and at the same time eliminate or minimize those which are untoward, the fishes must increase because that is all they can possibly do. We should not doubt, at least for the present, that the laws governing aquatic life are absolute. Therefore, the more of these laws we learn the more complete will be our control over the destiny of our fishes.

In a preceding paragraph I refer to controlling or limiting factors. The reason for this dual nomenclature is that of the factors which control production in any given body of water, only a few

I.

LAKE TABLE OF PROGRESSIVE FACTORS CONTROLLING PRODUCTION OF SMALL-MOUTH BLACK BASS.

[Symbols: E. A.—Effect absolute. V. D.—Varies disproportionately. E. V. D.—Effect varies disproportionately. E. V. P.—Effect varies proportionately.]

Controlling Factors.	Dependent Factors.																		
	Altitude.	Turbidity.	Temperature.	Depth areas.	Dissolved gases.	Current or absence.	Barriers or absence.	Bottom chemical areas.	Breeding areas.	Algæ.	Higher plants.	Scuds and waterfleas.	Insect life.	Snails and molluscs.	Golden shiners.	Fallfish.	Perch and sunfish.	Pickerel.	Small-mouth black bass.
E. A. altitude		x	x				x												
" turbidity										x	x								x
" temperature					x					x	x	x	x	x	x	x	x	x	x
" depth areas			x							x	x	x	x	x	x	x	x	x	x
" dissolved gases										x	x	x	x	x	x	x	x	x	x
" current or absence			x							x	x	x	x	x	x	x	x	x	x
" barriers or absence										x	x	x	x	x	x	x	x	x	x
" bottom chemical areas					x						x			x					
" breeding areas															x	x	x	x	x
V. D. algæ					x			x				x	x	x	x				
" higher plants					x			x				x	x	x	x				
" scuds and waterfleas					x			x							x	x	x	x	x
E. V. D. insect life															x	x	x	x	x
" snails and molluscs															x	x	x	x	x
" forage fish (golden shiners)																x	x	x	x
" swiftwater minnows (fallfish)																x	x	x	x
" table fish (perch and sunfish)																x	x	x	x
" other predatory fish (pickerel)																x	x	x	x
E. V. P. small-mouth black bass																x	x	x	x

This table is not presented as accurate, but is intended to approximate the main factors and stimulate thought along similar lines.

will actually limit it at any one time. Moreover, the degree to which limitation to the bass occurs is variable with the different factors. Some, as indicated by the letters E. A. on the Lake Table, have effect which is absolute; others lettered V. D.—vary disproportionately with the production of bass, but as they are considered present far in excess of the immediate requirements of the bass in the present illustration they vary only in disproportion, and not in effect until a shortage begins to occur. Others in the table are lettered E. V. D., meaning effect varies disproportionately within a short time. Only one factor affects the bass in possibly direct proportion to their increase, and that is the bass themselves.

Thus, to illustrate each case in different words: suppose we consider the Lake Table applicable to a lake where adjustments are being made to increase small-mouth bass. The effect of factors like (E. A.) altitude, turbidity, and temperature remain the same regardless of bass production unless we are able to change them. Factors like (V. D.) vegetation, free algæ and other early turnovers in the bass food supply vary disproportionately to the increase of the bass; but since the bass can not or do not quickly exhaust their beneficent influences, there is no untoward effect. Factors such as (E. V. D.) table fish and swift-water minnows which destroy young bass and compete with them for food will no doubt destroy or impair the maximum development of a greater number numerically as the bass increase; therefore their effect, since they were already a limiting factor before the increase of bass began, will be quite appreciable. The proportion destroyed, however, will probably be less as efforts are made to increase the forage fish and insect life (E. V. D.) on which both bass and hostile fishes feed. Therefore, the effects vary disproportionately with the bass increase. The last classification (E. V. P.), meaning effect varies proportionately, applies only to the bass in certain of their relations to one another; as to all other factors which the bass are capable of affecting, the increase continues disproportionate.

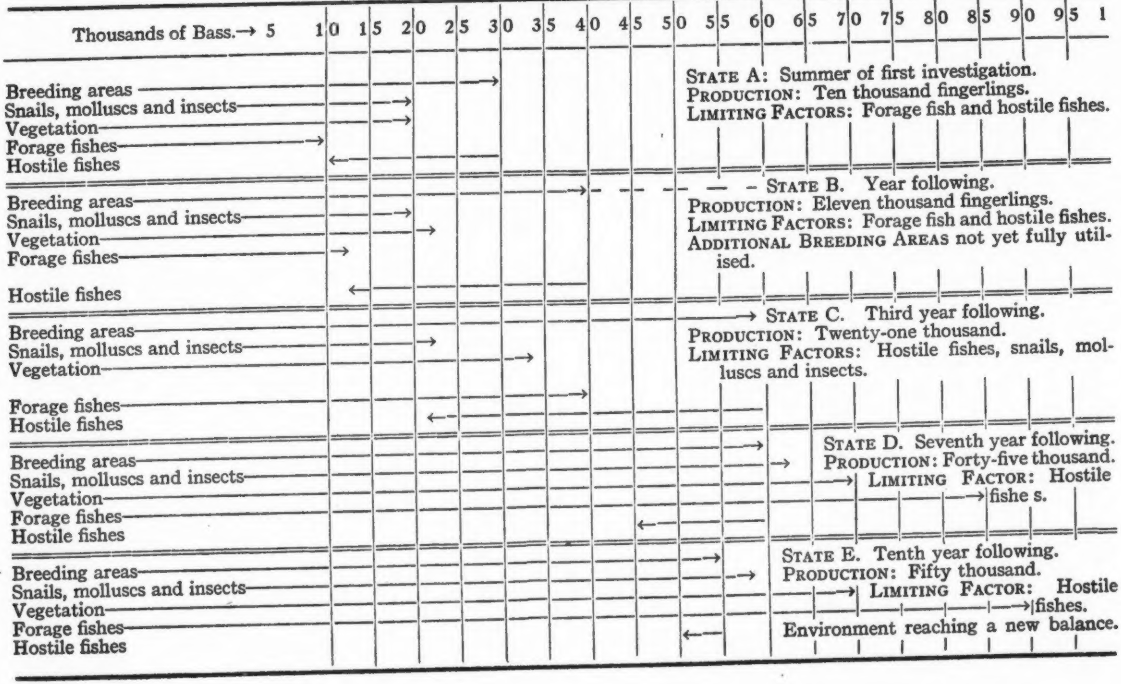
In analyzing these conditions as variously shown in the Lake Adjustment Reaction Chart (Table II), under the five divisions indicated as States A to E, inclusive, it would appear that during the summer of the initial investigation of the waters in question, the production of bass fingerlings was a hypo-

thetical 10,000 out of a hypothetical potential of 30,000 made possible by the number of eggs hatched on the available breeding grounds and remaining after other factors not shown in the chart had exerted their effects. Only 10,000 survive the summer; for, although there are sufficient snails, molluscs, and insect life to support 20,000 fingerlings to the summer's end, the supply of forage fish is so scarce that the hostile fishes, inclusive of the older bass, prey upon the fingerlings to this extent.

Assuming that in this particular case it is possible to double the available breeding areas by spreading gravel of the right sort at proper depths, or by raising or lowering the water level, this will give a potential (State B) of 60,000 fingerling bass within a year or two as excess breeders take up space and more fish arrive at maturity. However, as new species of vegetation, molluscs, and forage fish superior to those native to the locality have just been introduced, the change is not appreciable the first year following; and while an increase in the number of potential fingerlings is available from the increased number of eggs hatched, the hostile fishes consume the surplus nearly down to the old number of 10,000.

State C, however, shows decided improvement. The number of fingerlings made possible by the increased breeding areas is now at its maximum of 60,000. The superior species of vegetation which have been introduced are taking hold well and show improvement which is further evidenced by the great increase among the newly introduced forage fish. The latter, however, have kept the snails, molluscs and insect life retarded, though on the other hand they have forced the hostile fishes to slacken in their persecution of the bass fingerlings, over 20,000 of which survive the summer.

II. LAKE READJUSTMENT REACTION CHART.



This table shows production in thousands of fingerling small-mouth bass by length of arrows. Those to right indicate maximum possible production aided by the factors named. Arrows to left indicate direct limitation by factor named. Hence longest arrow from the right and shortest from the left are limiting factors.

Only five factors are dealt with in order to simplify the chart. The arrow from breeding areas represents eggs hatched converted to potential fingerlings after factors not shown in this chart have exerted their effect. Specific accuracy is not attempted, but the general reactions shown are believed by the author to be substantially correct.

In State D still further improvement is noted. The vegetation is now capable of sheltering and supporting more fingerlings than the potential provided by the full use of the increased available breeding grounds. The same is true of the snails, molluscs and insect life and the forage fish. As, however, increase in conditions favoring the bass have reacted favorably on the hostile fishes also, we find them increasing and holding bass production down to 45,000—15,000 below possible maximum under the present adjustment.

State E, the most interesting of all, is intended to show the gradual readjustment of the various factors to the new balance of higher production. Owing to the constant increase in vegetation, the forage fish, through the shelter afforded and food furnished, are at their maximum. The snails, molluscs and insect life, however, are decreasing on that account and the available breeding areas are becoming less, due to plant invasion. The increase in forage fish and efforts to eliminate fishes antagonistic to the bass has resulted in a decrease in enemy activity more than compensating the loss of breeding area and leaving the total number of fingerlings surviving the summer at 50,000.

These charts indicate that, unless the only limiting factor in a lake, pond, or stream is insufficient breeding areas, or other factor wholly effective before the stage at which plantings are made, it is a total loss to introduce young fish of species already established without making suitable adustments providing for them, since they will be consumed together with the percentage already being eliminated by other factors. Thus if there is a shortage of spawning beds and it remains unremedied, any possible gain to the angler even through lavish stocking is purely transitory, since the available breeding ground is the neck of the bottle through which any increase in mature fish must pass to become permanent.

As a matter of fact, shortage of breeding areas is seldom, though far from never, the difficulty, as the potential reproductive capacity of the bass (and most other fish) is so great that it never becomes an absolute limiting factor. More bass are, and probably always will be, produced than survive environmental elimination. However, an extension of breeding areas tends to be beneficial unless it cuts down on other necessary factors such as depth areas providing winter shelter, or chemical areas supporting submerged vegetation beyond the minimum of each essential to maximum bass support. In a natural, undeveloped lake, which will average 500 bass nests year in and year out, fished or unfished, providing the same is done at a constant rate, the saturation point of bass breeders may be said to approximate 1,000. That is, in spite of everything, 1,000 mature bass spawn in those waters every year.

Now on these 500 nests there will be 1,500,000 eggs if we take 3,000 as an approximate number per nest. Though the survival of bass from hatching to reproduction is sometimes referred to as less than 2 per cent, in reality the percentage reaching maturity and reproduction is in the neighborhood of .000269 or somewhat less than .0003 per cent. In other words, if 1,000 mature fish spawn every year they are made up of some which are spawning for the first time, some for the second, and some for the third and fourth times. I have no data on spawning ages so am leaving any earlier or later spawners out of the reckoning; but, as any fish spawning for the fourth time would be six years old, and in well-fished waters would probably not exceed that age, I think the figures are close enough. One thousand breeders would therefore (see Table III) probably consist of 50 six-year-old fish, 200 five-year-olds, 350 four-year-olds, and 400 new spawners. Thus out of the 1,500,000 eggs produced annually only 400 annually survive to reproduction, which gives the above percentage, and at the same time clearly shows, whether the figures are absolutely accurate or not, than the reproductive capacity of the bass is a tremendous potential and gives a glimpse of the wonderful advantages which are not only possible, but *positively await study and adjustment of environments.*

There is no reason why ecological adjustment of aquatic environments, including the fish life, cannot be made an exact science, but it will only become so by close and patient study

leading to complete knowledge of the relations which the species bear to each other and to the environment and application through the knowledge thus gained of the principles which mankind has applied through the ages in securing and maintaining his own supremacy.

III.
Potential and Mortality Table for Small-Mouth Bass.

Hatched: - 1916	1917	1918	1919	1920	1921	1922
Premise: 1,000 spawners on 500 nests each year, 3,000 eggs per nest. 1,500,000 eggs yearly.		Lines of Life.		Mortality before spawning down to .000269 per cent.		
First spawning	400	400	400	400	400	400
Second spawning	350	350	350	350	350	350
Third spawning	200	200	200	200	200	200
Fourth spawning	50	50	50	50	50	50
Total spawners yearly.	1,000	1,000	1,000	1,000	1,000	1,000

Assume a lake where scarcity of food, low temperature, or other environmental reasons defer spawning until the fish are three years old. If spawning starts sooner the proportion reaching maturity and reproduction is less than .000269 since the total number per year is one thousand, unless all die under six years of age, which is unlikely.

Mortality before spawning probably substantially correct. Mortality after first spawning purely hypothetical.

For many years it has been increasingly evident to those who have consulted old records, or otherwise kept in touch, that the supply of our native game fishes, particularly in the more developed parts of the country, has been steadily decreasing. The fact that this diminution has not attracted the full and responsive attention which it merits is probably due to a number of

reasons. For one, improved facilities of transportation bring formerly inaccessible places within easy reach, thereby preventing realization of the increased energy expended to obtain fish. For another, the changes coming with the slow passage of the years are usually so gradual as to deceive; but, should someone remember and speak of former abundance, what happens? The new generations of anglers growing up are inclined to regard statements of their immediate predecessors which concern larger catches, both in size and number of individuals, as intended more to impress than edify, or, if they do consider the statements as seriously intended, attribute them rather to that state of mind, sometimes found in those of advancing years, which rather fails to find anything quite so good or as plentiful as in years gone by.

Whatever the reasons may be, it is time that vigorous and cooperative action extending our fish culture to include progressive adjustment of waters should be taken by everyone who is in the slightest degree interested in the preservation of our fishes, especially the game species, from gradual but certain elimination. Inasmuch as streams are less subject to control than lakes, it is upon the latter that the first pitched battles in the coming struggle of defense must be fought. Our ultimate object should be to learn how to develop, from any starting point, the ideal body of water whereon the angler shall be the only limiting factor. The day may come when a war of conquest will carry our victorious arms, or fins if you prefer, into the great river systems, but for the present our backs are to the wall to win out on our ponds and lakes. It is here we must stand, and fall if necessary, to preserve one of the most remarkable heritages of fish life that evolution has yet produced.

Discussion.

Mr. C. F. Culler, Homer, Minn.: Mr. Brown spoke of the poor old carp. Did he mean to suggest that the carp was a bad citizen all over the country, or was he referring to some particular place?

Mr. Brown: I think in general that the presence of the carp has a bad effect upon our native fishes. In localities where other fishes would not naturally be able to maintain themselves, of course there would be no objection to the carp.

Mr. Culler: The poor old fellow has been condemned from all quarters, but have you ever stopped to realize that the carp and the buffalo in the Mississippi Valley are of the greatest economic value to that section of the country; that there are more pounds of these species of fish caught

and marketed in that section than any other kind; and that they reach a class of the people who could not afford a higher grade of fish? Also the carp furnishes food for the game fish. There is nothing more destructive to game fish than their own kind. For example, the pike will eat more fish in a day than you will eat in a month.

MR. BROWN: In regard to the use of the carp as a forage fish, I have run across that a number of times in the past year. Some people have advocated that the carp should be introduced into natural bass waters with a view to their young serving as food for the bass. I went extensively into the matter; and it would appear that as the carp increase, though they do not feed directly on the bass, they are nearer to the source of the food supply than the bass. The bass have to take their food after a number of turn-overs, whereas the carp can feed on the vegetation direct; the result is that as the carp increases in size and numbers—and there is a great increase when they first come in—they begin to compete with the bass. They tend to eliminate the vegetation by grubbing and rooting in the water, and they consume the roots. Dr. Osborn found, a couple of years ago, over five thousand seeds of plants in the stomach of a single carp. In this way the vegetation is gradually eliminated; and the turbidity of the water, created through the operations of the carp, has a very deleterious effect on bass eggs, also on the young bass—particularly the small-mouth. In addition to this, the turbidity of the water enables swift water-minnows, such as chubs, redfins, fallfish, and so on, to operate as if under a smoke screen and to take the young bass. The consequence is that the partial protection ordinarily afforded by the mature bass to their young is done away with.

MR. CULLER: Why not hatch them out under proper restrictions? When it comes to sport it is hard to beat a 10-pound carp. I have got them on live minnows, and I have had some sport with a 10-pound carp; you cannot land him unless you have a net. In fact, I have had more sport with a 10-pound carp than I could have with a 5-pound bass. You cannot land a carp as you land a salmon.

MR. BROWN: What kind of minnow did you use for bait?

MR. CULLER: Chub.

MR. BROWN: How big a fish was it?

MR. CULLER: The chub—about 3 or 4 inches.

MR. BROWN: Then it would appear that the carp do eat live fish.

MR. CULLER: They will eat live bait in certain places—in the rivers; that was in the Mississippi River. But do not crush the old fellow out; give him a show.

DR. EMMELINE MOORE, Albany, N. Y.: I have been very much interested in the hypothetical problem that Mr. Brown has projected and the very interesting and intelligent way in which he has analyzed the steps in the solution of that hypothetical problem. But I feel that his conclusion is weak in one respect. He states that this hypothetical pond or lake will have, when it is properly adjusted, only one limiting factor, and that is the angler. I cannot quite see how, in a pond so intensively cultivated, the only limiting factor would be the angler.

MR. BROWN: I expressed the idea that such a thing would be possible

and that we should work toward that end; but the probability would be that we might never reach our objective. As said in my paper just read, our ultimate object should be to learn how to develop, from any starting point, the ideal body of water whereon the angler shall be the only limiting factor.

MR. C. O. HAYFORD, Hackettstown, N. J.: I think we are very fortunate in having Mr. Brown give us this paper. I have known him for a number of years. Up where he comes from they have a very large lake and from the time he was a boy he has had a wonderful chance to observe the fish life in that body of water. He became interested in this subject, as few boys do; it has been a hobby with him from the start. He informed me the other night that he was going much further with his studies. It is remarkable the extent to which he has taken the time to count and study the fish nests, and do many of the things which he has discussed with me. I hope Mr. Brown will continue along this line and later give us a further account of any developments in the valuable work that he is carrying on.

DR. E. E. PRINCE, Ottawa, Canada: I would like to say one word in commendation of this paper. It seems to me to be an admirable supplement to Dr. Birge's paper of yesterday, because after all, when we come down to these questions of adjustment, we must know the chemical and biological factors that lie at the bottom of it all. As Mr. Brown has said, there are many factors to be considered, none of which you can ignore. There is especially the question of new diseases, new troubles that arise from our artificial adjustments; because after all we are aiming at keeping up the proper natural balance of factors—a very ideal condition of things. While Mr. Brown's paper is highly theoretical in its character, it is not entirely so; there is a basis of fact there. I have often thought that in surmounting the difficulties which arise from over-fishing and from changed ecological conditions, the ideal to aim at is not always that of simply making a certain body of water self-producing or self-reproducing. I call to mind certain bass lakes in Canada and one or two very important brook trout waters which are well stocked with fish, but the young fish are reared in other waters and brought there to grow to maturity. Let me illustrate: We had a bass pond in Ontario in which we placed a great number of parent fish just before the spawning time. They nested there, and the young hatched out. We immediately removed all the parent bass and left the young in this admirable pond, which was well supplied with the natural food. On some of my visits to that nursery I found the pond actually black with young bass. Now, the parents were put into the main lake, where they were accessible to the angler. When the young bass were two or three inches in length, then we transferred them to the open waters. It was a solution of the problem of keeping up the supply of fish where it is a very difficult thing to balance all the ecological conditions for parents as well as fry in a large open lake. Similarly brook trout were reared in a stream and subsequently planted in another region, but it was found especially successful with black bass. The angler got a much better supply of fish through the use of this method of providing a nursery separate from the fishing waters. I wish personally to thank Mr. Brown for his admirable paper.

PROTECTING MIGRATING PACIFIC SALMON.

By John N. Cobb

Director, College of Fisheries, University of Washington, Seattle

The remarkable development of irrigation and power projects, especially in the country west of the Mississippi River, has brought to the fore a number of perplexing problems in connection with our fish life, and unless these can be satisfactorily solved our economic and game fisheries are threatened with extinction or heavy loss. This is especially true of the Pacific Coast, as in nearly all of the rivers debouching into the Pacific Ocean occur annual runs of anadromous fish, comprising the five species of salmon, also steelhead trout, smelts, sturgeon, lampreys, and others. In this connection the writer has thought that the members of the American Fisheries Society might be interested in what we have done in the State of Washington to safeguard the runs in the Yakima River, one of our typical streams.

DESCRIPTION OF THE YAKIMA RIVER.

This river rises in the Cascade Range, near the Snoqualmie Pass, flows in a southeasterly direction in Kittitas, Yakima, and Benton counties and empties into the Columbia River about 10 miles above the mouth of the Snake River. The approximate length of the river is 180 miles, and it has a drainage area of 5,970 square miles. It has a number of important tributaries, including Naches, Cle Elum, Kachess, and Teanaway rivers and many large creeks. The river water is remarkably clear and cold. The river is subject to frequent freshets during the rainy season, and as a result of the melting snow in the mountains there is a good flow of water even during the dry season in the lower reaches.

HABITS OF THE MIGRATING FISH.

In order to understand the magnitude of the task it is necessary to describe briefly the migrations of the salmon, which comprise the vastly greater part of the migrants.

It is the custom of the salmon, when it reaches the adult stage, which period varies with the species, and also within a limited range in the case of certain species, to leave the salt water and head for the certain stream in which it was born, or

in which it was planted. How it finds this particular stream out of the many, is still one of the unsolved salmon problems, but find it we well know it does. As soon as the salmon reach the brackish waters they cease to feed, and from this until the end no food enters the stomach. After a period varying with the species and the length of the stream, those that escape their many enemies reach the spawning grounds. Here they remain until the eggs and milt are ripe, when the reproductive act takes place. From the moment the fish enters the fresh water a sort of decay of its body sets in. Gradually the body loses the bright, silvery appearance it had when first coming in, and replaces it with a reddish, sometimes a deep red, color; the scales gradually fuse into the skin, the upper jaw becomes elongated and hooked, in some dead white blotches appear on the body and these spread so that finally the whole body appears one dead white blotch. As the fish has ceased to eat, the stomach and intestines, through disuse, shrivel up until it would be difficult to insert a pencil point into them. Still other changes are noticed in some species. But the above is ample to prepare the reader to learn that all of these fish die after spawning.

As a result of this it is not necessary for us to assure a return passage to their ocean home for these hordes, but it is necessary to do so for their progeny. The eggs deposited by the female find shelter in the pebbles at the bottom and those that have been fertilized and escaped their enemies hatch out in approximately three months time. They are born with a yolk sack and during the first 30 days they live by absorbing this, after which they must shift for themselves. The humpbacks and dogs go to sea as soon as possible after the sack is absorbed, while the others remain in the fresh waters varying periods, ranging from three months to sixteen months after birth.

SAFEGUARDING THE MIGRATING ADULT FISH.

From the above it can easily be perceived that our first task is to assure a safe passage to the spawning grounds of those fish which escaped their many enemies in the main Columbia River. No commercial fishing is permitted in the Yakima River, although Indians catch them for home use, and occasionally to

sell, with spears in those stretches of the river abutting on Indian reservations.

The first obstruction to the ascent of the fish is at Kennewick, close by the mouth. Here a dam 42 inches in height has been constructed to obtain water for irrigation purposes. The next obstruction is at Prosser, where a dam was constructed some years ago in order to supply power to operate a mill. This dam has a fishway of the pool and fall system.

At Wapato, on the Yakima River a few miles below the city of Yakima, the United States Indian Service some years ago installed a dam in order to supply water to irrigate land on the Yakima Indian Reservation. A couple of miles farther down, at Sunnyside, the United States Reclamation Service about the same time built another dam to irrigate land outside the reservation. In the upper dam was constructed one of the finest pool and fall fishways the writer has ever seen, being made of cement, of ample dimensions, and having an excellent system of control gates at the head. In the other was installed a narrow, shallow pool system, with openings at the bottom of the pools, and with no control gates at the head. As a result there was a steady, regular, and ample flow of water through the Wapato fishway, while in the Sunnyside there was a seething and wild flow, especially when the water was high, which any fish accustomed to jumping would have had much trouble in combatting.

For a considerable time fish culturists paid but little attention to the river, in fact they hardly thought of it, as but little attention or consideration had been paid to them when the dams were constructed, and it is still a puzzle in one or two instances where the builders got their plans for the fishways that were installed. If biologists thought of them at all, it was doubtless to feel that expert advice had been asked and acted upon and that all was well. A few doubting Thomases, however, insisted upon being heard and claimed that the fishways were not doing the work they were installed for. About a year ago Mr. J. W. Kinney, who had assumed office a few months before as State Supervisor of Game and Game Fishes, put the matter of ascertaining the facts in the case up to the writer, who was also authorized to apply such corrective measures as might be needed.

The first task taken up was the determination of the effec-

tiveness of the established fishways. Observation at the Wapato and Sunnyside dams developed that many fish were to be seen jumping at both dams when the annual runs were on, and it was noticed that quite a few managed to get over the dams in this way, and the bigger the flood in the river the easier it appeared to be for the fish. In order to determine whether fish were passing through the fishway of the Sunnyside dam, last spring, during the steelhead run, a trap was placed at the upper exit of the fishway. This trap was left in for several weeks, and during that period not a steelhead was captured, the catch consisting of squawfish and suckers, none of which are inclined to jump out of the water. During this period plenty of steelheads were, however, observed jumping along the face of the dam.

Previous investigation elsewhere had developed that the fatal weakness of the standard type of pool and fall fishway is that the entrance to the fishway is so far downstream that salmon and trout almost invariably miss it, and the writer is impelled here to express the fear that but few species of fish other than suckers and squawfish would be apt to find it.

During the preceding winter a plan radically modifying the pool and fall system had been prepared and the modified fishways are now under construction in both dams. In this the device is carried a certain distance down stream, then turned at right angles, thence turned again to face toward the dam, and carried back to the foot of the apron of the dam. This makes a structure resembling a staircase with one acute turn and landing and in this way reduces at least one-half the extreme distance of the fishway below the dam. By making the entrance to the fishway parallel to the face of the dam and just at the foot of it a convenient and easily found gateway is provided for the salmon to enter. A somewhat similar plan has been found to work successfully in the Ament dam on the Rogue River in Oregon, near Grants Pass, where it superseded one of the old type which had proved worthless.

As the Sunnyside dam is quite wide, while the river just below it is broken up into pools and shallows, it has been decided to also construct another fishway of the modified type on the western side of the dam. In the new pool and fall system being installed in the Wapato dam, the pools are 7 feet long by 8 feet wide by 4 feet deep while the openings for the water to

pass from one pool to another are 2 feet wide and one foot deep. In the Sunnyside fishways the pools will be somewhat smaller in the old one, due to the fact that it was thought best not to alter the upper half too much as it is in this case, as well as in that of the Wapato, to be incorporated into the new system.

Another arrangement of the pool and fall system which has been found to work well in certain places is that which has its entrance in the face of the dam at one side. This type is in use in the dam and locks of the canal connecting Lake Union with Puget Sound. Here the high bank on one side and the wall of the lock on the other side confine the fish in a channel about 150 feet in width, and as the water is deep along the bank the salmon are easily led to the mouth and thence induced by the flow of water from the fishway to jump into the first box, and thence up until they swim away into Lake Union, some distance beyond the top of the dam. In many instances this will be found a more feasible and practicable system than one located wholly below the dam, and it is our intention to use it whenever possible.

At this point it might be well to emphasize a fact soon discovered that only up to a certain point can the fishway be standardized. There are no two dams constructed exactly alike, and it is but rarely, if ever, that the effects produced by a dam upon the river itself are uniform. As a result each project must be considered as an entirely separate and distinct problem, which must be attacked all over again, and such modifications in the regular type of fishway made as investigation develops are needed, and the solving of this problem is preeminently the work of the biologist.

The fishway in the Prosser dam was about as worthless for migration purposes as the one in the Sunnyside dam, and last year a considerable section was torn out and the fish now have no trouble in passing through the sluiceway so made. In the Kennewick dam a sluiceway about 50 feet in width in the center of the dam has been provided. In order to prevent too rapid flow of water through this for the fish to breast, three baffle boards, two on one side and one about midway of the others and on the opposite side have been provided.

In the endeavor to evolve the best type of fishways for the dams on the Yakima a number of plans were prepared, and the best of these, in the writer's opinion, had to be abandoned be-

cause the owners of the dams were unwilling to allow the installation of anything that required any considerable cutting into the dam. One of these provided for a tunnel under the apron and the dam itself, and the installation of an enclosed pool and fall fishway along the upper side of the dam, with an opening upstream at the crest of the dam. This opening was to be safeguarded from debris and was to be provided with gates for controlling the supply of water entering therein. The entrance to the fishway was to be at the head of one of the deeper pools in which the fish generally congregated.

SAFEGUARDING THE YOUNG ON THEIR SEAWARD WAY.

After provision had been made as noted above for the ascent of the adult fish, it was necessary to safeguard the young fish on their way to the sea, their natural habitat.

When the course of the river was unobstructed the little fish usually came down stream in schools in the late spring and early summer. When small tributaries were encountered many of the fish would ascend these for some distance, or play around inside their mouths, to later resume their interrupted journey. For irrigation purposes large ditches, some of them carrying an immense volume of water, are constructed and the entrance to these is at one or the other side of the dams. They are protected by large gates, which are raised to a height sufficient to permit the volume of water needed to enter under them. From these main ditches innumerable distributing ditches radiate and thus carry the life-giving water to the thirsty fields in the area covered by the project. Water is usually turned into the ditches early in April and shut off about October.

If these main ditches are left unguarded, the young fish appearing a month or more later are almost irresistibly drawn into them by the strong current and in a very short period of time the younger ones have been carried through the various feeders to ultimately find an untimely fate on the fields. Should the larger and stronger ones be enabled to keep out of the smaller ditches which lead directly onto the cultivated fields, their fate is merely postponed until the water is drawn off in the fall, and they are left to die in the rapidly-drying ditches. We have ocular evidence that many millions of young salmon and trout have met such a fate. This has been a terrible drain on the Pacific salmon runs, and while numerous attempts have been

made to find a way to stop this sapping of our fishery resources, it must be reluctantly confessed that the burden has fallen upon our fish culturists, who have had almost no aid from the agriculturists; in fact, the latter have frequently fought the remedial measures applied, and it has been necessary to require by law that some preventive measures be adopted in such ditches.

One of the earliest safeguards employed was the placing across the mouth of these ditches of a heavy wire screen of small enough mesh to prevent the fish from getting through. The principal disadvantage of this device was that floating leaves and other debris gathered along its face and sometimes almost formed a dam of it, and it proved a difficult matter to keep it clean. A big wheel, the full width of the ditch, and with a fine mesh covering, was then devised and this was found to work better than the screen, as the revolving of the wheel due to the force of the current prevented part of the debris from accumulating on and against it. While a number of these are in use they have been successful only in a measure, and the same objections have been made against them that are made against the screen.

Several years ago W. J. Burkey, of Berkeley, Calif., conceived the idea of an electric fish stop, and shortly afterwards got in touch with the Yakima County Fish and Game Commission. In 1920 he came to Yakima and installed one or two of his devices in irrigation ditches nearby. At this time the device was an exceedingly crude one, and a little experimental work soon developed that while it had some merit it would have to be greatly improved to do the work desired. Shortly after this the Yakima County authorities purchased the county rights for the use of the device. The State Department of Fisheries assigned an electrical expert to the work of perfecting it and he and E. C. Greenman, County Game Warden, worked with the device for several months and finally produced the one now in use.

The present electrical fish stop consists of from two to four rows of iron or steel spirals, placed in a vertical position, and from two to five feet apart both up stream and across and extending from about six feet above high water mark to the bottom of the ditch. These spirals are held in position by means of a wooden frame which stands entirely out of the water and is placed across the canal above the headgates. An ordinary light

drop of low amperage, and a voltage of 110 to 120, connected to the spirals or electrodes will furnish ample electricity. If a power line is not available, electricity may be supplied by a small generator driven by a water wheel or gas motor. Copper wiring is connected to the tops of the electrodes, and electrical current is shot in all directions through the canal in a zone of about twelve feet up and down the ditch, and the County game authorities claim this is sufficient to turn back all fish entering.

The writer has visited these devices a number of times, but has not yet been fortunate enough to witness the actions of fish when coming into the charged zone. Those, however, who have witnessed them claim that as the young fish drift tail first down the stream they are seen to be affected when some feet away from the device and immediately swim away from the affected zone. It is said that when the device was first put in and charged young fish were at times seen around the electrodes and the force of the current was sufficient to knock them senseless, but they soon recovered after drifting out of the charged area.

In 1921 the devices were put in the ditches several weeks after the water had been turned in and thus it was impossible to tell whether the very few fish found in the ditches when the water was turned off in the fall had got in before or after the devices were installed. This year, however, the devices were in place when the water was turned in and conclusive evidence of their efficiency will be afforded during the summer and after the water is turned off in the fall.

Discussion.

Mr. J. N. Cobb: I am preparing now a comprehensive report on fishways of the Pacific Coast. The engineer who has been working with me for some time on this problem under my direction has prepared a number of plans. I am holding the report up until we test out one or two of these devices, but I can assure you that I shall be only too glad to place at the disposal of those who are interested any of the plans prepared. I have gathered, as far as I could, plans and specifications of other fishways, and would like to enlarge this collection. If, therefore, any of the members here know of fishways that I can get plans and specifications of—whether they work or not—I should be glad to hear of them; because I would like to know what is good as well as what it is wise to avoid. I never knew of a fishway that was thoroughly satisfactory, while many of them have been absolutely worthless.

Mr. Carlos Avery, St. Paul, Minn.: Perhaps we are inclined to give up the struggle with reference to fishways in this section of the country

too soon. We have been inclined to the conclusion that it might be useless to attempt further work with fishways in the streams in our section of the country where we have the more sluggish fishes—the pike perch and other fishes which do not leap and perhaps would not adapt themselves to the style of fishways that Mr. Cobb may have found successful in his streams. But his work indicates that perhaps we ought to make a more thorough and scientific study of the question here. I have in mind one fishway on the Mississippi River through which the pike perch pass in large numbers; we have found that by observation—but it is one of the very few I have heard of that pike perch would use. If we can, as he suggests, by studying each individual case more thoroughly, devise a fishway through which the fish will pass, we shall have done something to meet a very large demand. We have been importuned to require the installation of fishways in dams, but on account of the failure of most fishways we have been inclined to discourage any further efforts along that line.

Mr. N. A. Comeau, Godbout, Quebec: It has been possible for me to build two fishways on Canadian rivers, one on the Sheldrake River, about 15 miles from my place, and another on the Matamak or Trout River for Mr. Copley Amory, of New York. Both of these fishways have been a success. Three hours after I put the fishway on the Sheldrake River the fish were ascending. I would be very glad to give you a plan of these fishways. The fall on the Sheldrake River was 24 feet, over a great granite cliff; on the Matamak it was 28 feet. I built the fishway in the solid rock.

Mr. Charles O. Hayford, Hackettstown, N. J.: Maine has a number of successful fishways of various heights, for landlocked salmon and trout. I had charge of one located at the outlet of Rangeley, where many trout and salmon ascended annually. The dam was 12 feet high. My experience with fishways has taught me that currents have a great deal to do with their success.

Mr. G. C. Leach, Washington, D. C.: It is my opinion that a fishway is of little value except for anadromous fish; and even then I believe that, having regard to the cost of maintenance of the fishway and interest on the investment, that in a great many cases a man employed to seine the fish from below the dam will put more fish above than any fishway. So far as the more sluggish species are concerned, I think the dam is a pretty good thing in the streams; it forms them into pools and places which you can stock with fish. In this case I believe you get better results than may be obtained, as a rule, in the ordinary open stream.

Mr. Dwight Lydell, Comstock Park, Mich.: We have a dam in Michigan on the Pine River, known as the Welston dam, that is about 40 feet high; and at this place there is located one of the collecting stations for rainbow trout eggs. On one occasion when I visited the place we opened the upper trap of the dam, where the fish make the final leap into the water above, and we took out of it 50 rainbow trout; so I have always considered that our fishway there was working to perfection. The only thing was that we had to close it in order to get any fish below the dam. This fishway is composed of a lot of large boxes and the fish jump from

one to the other; they also have a place to rest. Particulars as to the construction of this fishway can be obtained from our department.

Mr. J. N. Cobb: Our irrigation projects do not bother us so much, because the dams are all low. But I have now at my office an application for a fishway or some way of getting the fish over a dam 110 feet high. The projectors expect to take every drop of water out of the river on which the dam will be located, and run it through a sluiceway to the power plant, which will be located on salt water. We have at present in use a power project with a dam 200 feet high; they put a fishway in the dam, the entrance to which is nearly 600 feet below the apron of the dam. The State Fish Commission uses it mainly for the catching of squawfish and suckers. About half way up the fishway a gate cuts off the ascent of the fish, and when the suckers and squawfish get up there they are removed. Nobody has ever seen a salmon or trout go up this last fishway. We don't find as great a difficulty in getting the adult fish up and over the dam as we do in getting the young fish safely over it on their downward migration. There is a sluiceway in the Sunnyside dam, but it is too swift for fish; there is always a heavy flow of water through it—the less water they have in the river the more there is in the sluiceway. They want to use as much as possible of the run of water through the ditches and as little as possible over the dams. But we have had the assurance from the United States Reclamation Service that no more irrigation projects will be considered unless the problem of how to get fish over these dams is considered at the same time.

Dr. E. E. Prince, Ottawa, Canada: The points raised in Mr. Cobb's communication we in Canada have faced for a good many years. We have approached this fishway question, it seems to me, from an entirely wrong standpoint. Every species of fish has its own peculiar susceptibilities and methods, and the same mode of ascent apparently does not suit all.

Mr. Cobb has told us that every dam is different; there are no two alike. There is also the engineering difficulty; I do not see how you can erect a fishway in a strong dam without weakening it from an engineering standpoint. Many members of this Society will remember that four years ago I made a proposal to lift the fish up mechanically*, but I confess that I have been disappointed in receiving little encouragement from anybody in regard to this device of mine. If you can lift fish a height of 10 feet you can lift them with the same device a distance of 100 feet. Apparently most fish culturists think it is the wrong way of solving the difficulty; they want to make the fish go up themselves, whereas I want to elevate them mechanically. Mr. Cobb has mentioned the building of dams over 100 feet high. Well, if you let the fish climb up that height by a ladder or pass you provide a trap from which any poacher can take the fish. The longer the fishway the more opportunity there will be for them to take the fish out. Fishways are often in out of the way places and very hard to protect. Again, in Canada—and I suppose you have the same in many states—we

* See Trans. Amer. Fish. Soc., Vol. XLVIII, No. 3.

have the difficulty in winter of ice forming at these obstructions, with the result that many of the fishways are broken up or carried away.

As to the electrical screens, an electric shock seems to me to be a rather harsh method of driving fish away. It may work all right, but I think the simpler method of a revolving wheel or screen would be satisfactory; it has worked quite well in some of our western waters. I should like to ask Mr. Cobb what kinds of fish he was particularly referring to as making the ascent.

MR. J. N. COBB: I was referring to the chinook salmon, the silver or coho, and the steelhead trout. The red salmon does not run up that stream, nor does the dog salmon or the humpback. I assure Dr. Prince that I do not think the fish suffer from electric shock; it simply causes them to feel a tickling sensation and induces them to move on. We have never seen one killed, because the shock is very slight. Some which were playing around the electrodes were merely knocked senseless. They drifted away, but as soon as they got beyond the influence of the current they revived.

IRRIGATION CANALS AS AN AID TO FISHERIES DEVELOPMENT IN THE WEST.

By Prof. E. E. Prince, M. A., LL. D., D. Sc., F. R. S. C.
Dominion Commissioner of Fisheries, Ottawa, Canada

It has frequently been said that irrigation schemes on a large scale in western sections of the United States and Canada, while they may be the hope of Agriculture, are the grim despair of the Fisheries. "You cannot hope to have an abundant supply of fish in the same areas as you have irrigation reservoirs and canals," is the assertion of many well-informed people. That it is a grave question for our population in the Western States and Canadian Provinces cannot be disputed. A well-known Canadian railroad official, frankly declared ten or twelve years ago before a Fishery Commission, of which the Canadian Government had appointed me Chairman: "You cannot have irrigation and fish." It is because I hold the opposite opinion that I have brought the subject to attention at this time.

After viewing the matter from a variety of standpoints, I can see no insurmountable difficulty in providing a supply of fish for the people's food, and even a supply of certain game fish, if the conditions are observed, which are set forth in this paper. During my visit to Australia in 1914, when I paid special attention to the fisheries there, I found vast irrigation schemes on foot which involved the erection of huge dams, and extensive retaining reservoirs, but the conserving of the fish had never been ignored, and I may point out that the famous "Murray Cod," one of the most delicate and delicious of food-fishes, was the principal species in the South Australian waters where irrigation plans on an immense scale were in progress. Of course, like most great rivers in Australia, the Murray River, though it is 1,200 miles long, dries up to a large extent, forming a chain of lakes 40 to 50 feet deep; yet the Murray Cod, really a Serranoid, has continued to abound, the periodical droughts not having killed off the supply. There are always ample areas of water sufficiently deep remaining to furnish favorable conditions for the fish until normal conditions return with the wet season.

IRRIGATION SECURES PERMANENT RESERVOIRS.

The object of irrigation schemes is to prevent total drought

conditions, and to hold back ample supplies for distribution over arid regions. Just as great cities, in most countries, have created water-storage reservoirs, often very extensive ones, to guard against failure of drinking-water supplies for the citizens, so irrigation secures water for the farmer's crops.

My first point is that, apart from the ultimate object of this storage of water, these schemes create new possibilities for fisheries, fish-culture, and fish-conservation. In some countries these city reservoirs have been stocked with fish, and the issue of fishing permits has not only provided a coveted form of recreation, but has yielded a substantial annual revenue to many cities. It has not been found that such fishing has affected the quality or purity of the water for drinking purposes; indeed by permitting angling, and thus keeping the abundance of fish in check, numerous noxious animals and plants have been destroyed by the fish, and all ground of fear on the part of supersensitive citizens has been removed. Some large cities in England have encouraged anglers to resort to these storage reservoirs. Such a populous city as Leeds in Yorkshire has done so, and few large communities have better drinking water than the town referred to. In certain cases I know objections have been raised, as in the State of Connecticut, where systematic netting is carried out officially, and the catches are transported alive to various lakes and rivers in the State, and a system of extensive stocking is made possible. Angling was forbidden in the reservoirs, but they were utilized as supply-ponds for planting sporting waters, and the overcrowding of the reservoirs with fish was prevented.

INJURIOUS EFFECTS OF IRRIGATION.

I am well aware that irrigation of "dry belts" has caused great damage to fish. Twenty years ago the venerable Dr. James A. Henshall wrote, in reference to fish in Montana waters especially,

> It is disheartening and discouraging to the Western fish-culturist to know that millions of fish, both large and small, annually perish through being stranded on meadows and grain fields, as a result of unscreened ditches.

A Canadian Fisheries officer in the Province of Alberta, Mr. M. T. Miller, stated at the Fishery Commission's sittings in 1910:

> The irrigation ditches have been a great cause of destruction, especially in earlier days, owing to fish passing out of the laterals. I had instruc-

tions, as a Fishery Officer, to secure the screening of ditches, and some men did it, but others refused.

One complaint has been that dams erected for irrigation have prevented fish from getting up important creeks, which they had been accustomed to ascend. At Maple Creek, in Southern Saskatchewan, about 200 miles east of the Rocky Mountains, the statement, which I have before me, is that fish are held back below the dam, and die in such numbers as to be a nuisance, and that the Commissioner of Irrigation being asked to report, obtained evidence from local parties asserting that before dams were placed in the creek, fish ascended each season as far as they could; but now, since the cattle company had constructed irrigation dams, the fish were stopped, and died below. Thus fish are either obstructed and held back when migrating and die, or they are carried down the ditches, and along the laterals to be scattered over the land where they perish.

SCREENS ARE NECESSARY.

Both the evil results mentioned can be avoided by providing suitable screens. In general such screening is not difficult, though trouble and expense cannot be entirely avoided. There are cases, it must be admitted, where the difficulties cannot be ignored, particularly in very large reservoirs and canals. As an example I may mention the Bow River scheme in the Province of Alberta. The maintenance of screens in canals of large capacity presents difficulty, but not insuperable difficulty. The gates are four feet wide, with a ten-foot head of water, and no less than 1,500 miles of ditches can be supplied, under this plan operated by the Canadian Pacific Railway Company. It should be possible for a company of such importance, immense capital, and enlightened enterprise, to devise and install screens, not at the actual intake, but below the first water-gate. The placing of the screens should be decided in all cases by competent engineers furnished with discretionary power. The public and the sporting section of the community have undeniable rights, and estimates of the cost of effective screening, even on the largest irrigation systems, can be shown to be a very insignificant item annually, compared with the beneficial results to the general public.

IRRIGATION IN FOOTHILLS AND PLAINS.

In the hilly regions, among the western foot-hills, the question is not identical with that on the level prairie. Where the water-supply comes from swift mountain streams, the character of the water, and the kinds of fish, are in contrast with those of more sluggish and warmer water courses, meandering over the plains. Superior species inhabit the foot-hill streams, which are more esteemed by anglers and more valued on the table. The game cut-throat trout or red throat, the fastidious and famous grayling, that is to say the true northern grayling, not the Rocky Mountain whitefish, also known as Williamson's whitefish, which is popularly called grayling in the West—these are among the fishes which make their home in the rapid streams of the hilly territory. The slower sluggish water courses over the prairie are characterised by pike-perch or dore (the wall-eye), jackfish or long-nosed pike, yellow perch, the silvery herring-like gold-eye, various catfishes, mullets, and many species of suckers, and, in some localities, the fresh-water ling or cusk, all of which fish, at some season of the year, especially in the colder months, are very fair table fish, and even the least esteemed can be so prepared by salting and kippering as to be very palatable.

IRRIGATION RESERVOIR DAMS MAY BENEFIT FISH.

The erection of dams and the blocking of even important streams is not always a detriment, for the retention of a large body of water may provide more food, cooler conditions, and more ample environment for fish, and result in the production of larger fish and a more abundant supply of them. Local conditions vary, and a condition that may be injurious in one locality may be actually beneficial in another. I can recall two cases of substantial benefit to the fisheries due directly to the erection of dams which had caused great complaint on the part of mistaken enthusiasts. Thus in a stream in Guysborough County, Nova Scotia, small trout abounded, though at certain seasons some large sea trout ascended and later descended and returned to the sea; but after the erection of a dam for logging purposes, the body of water above was increased, and the trout retained in this deeper water increased in quantity and became of much larger average size, so that the anglers who complained of the dam at first, readily admitted the substantial benefit to fishing which

had resulted. In the Grand River in Ontario a dam was erected near Dunnville. Owing to complaints that fish could not migrate up the river, and that the dam obstructed ascending schools, a fishway was erected; but proved wholly useless. Fish, however, above the dam began to increase, and angling greatly improved, for such species as black bass and pike perch spawned, and the schools of young were retained and could not leave the river; hence the fishing was in every way benefited. The local anglers appreciated the situation, and adopted a system of netting bass and other fish below the dam and transferring them to the deeper waters above, where they permanently remained. Now, the canal and reservoirs which form so important a part of all schemes of irrigation provide the very conditions for similar fish culture work. As a rule the lakes and streams in northern areas, where irrigation systems are being carried out, are shallow, often not very pure, frequently affected by saline and alkaline elements, reduced or dried up in summer, and frozen to the bottom in winter, and thus afford every condition unfavorable for fish. A wholly new condition is created by the construction of canals and reservoirs under irrigation schemes. Large bodies of water, deep, cool, and free from excesssive impurities are created, and a great opportunity arises, therefore, for turning them to account as fish-producing constructions. Irrigation canals might become angling reserves, or, if of larger dimensions, sources of fish food for the communities in which they are located.

What then are the possibilities of securing fish production in such larger reservoirs or canals? Insect food usually establishes itself in a very short time, often in a few months after water is admitted; various fresh-water mollusks, water snails, etc., are carried by birds, and rapidly become numerous. But the food conditions necessary for fish could be hastened by the transference of such aquatic life from other waters. Species of small minnows (always excluding the destructive and harmful sticklebacks, small fish with three or more sharp spines on their back) will require to be introduced in most cases, as there are few large kinds of fish which do not prey upon these small species or feed upon their spawn and diminutive fry. But the question of food for fishes need cause no concern as both minnows and insect food and water snails will rapidly increase soon after they are introduced. It must, I fear, be taken for granted that

the finest game fish, such as the various western trouts and graylings, are not suitable. They must have rippling, rapid water, gravelly shallows, and the conditions generally which are characteristic of mountain streams. The eggs of such fishes also are deposited, and the young fish hatch out on sandy or gravel areas where the water is swift and aeration is assured, and subdued sunlight has access to hasten incubation.

YELLOW PERCH PRESENT ADVANTAGES.

There are many species of fish which deposit their eggs in glutinous masses, and which do not usually occur in rapid water. The yellow perch (*Perca flavescens*) has desirable qualities rendering it suitable for comparatively still waters. It is a handsome active fish, a good "pan fish," and affords considerable sport especially when it takes the fly—the black bass flies being the best. The eggs occur in tenacious ribbon-like masses, which cling to water plants, submerged posts, etc., or may even lie folded in a circular form on a soft muddy bottom, where I have often procured them in an advanced hatching condition. They take five to ten days only to incubate, and the young fry are unusually transparent and minute, and well fitted to escape the notice of many enemies. They are so prolific and hardy that the species is entitled to favor in spite of its low esteem on the part of many anglers, and also on the part of epicures because of its numerous small bones which are a trouble when it appears upon the table.

Its fighting qualities are undoubted. I have hooked a yellow perch of one and one-half or two pounds in weight, when fly-fishing for black bass in the swift clear waters of the Upper Ottawa River, Ontario, and I imagined, at first, that a good bass was at the end of my line. But after much powerful tugging, and many vigorous "rushes," he failed to "break water," and I soon realized that my victim was not a bass. When taking the fly it proves a really good game fish, and is, as I have said, so hardy and so prolific that it may be regarded as an ideal species for many irrigation reservoirs and canals. The only danger may be its tendency to spread, and it hatches out so rapidly that it soon over-runs adjacent waters, and finding its way into trout or bass waters has proved undesirable on that account. Of pike or jackfish, suckers, and other kinds of what are called "coarse

fish," all producing tenacious eggs, usually in gummy masses, I need say little. Their sporting qualities are inferior, and in southerly areas they are soft and poor flavored. "Poisson mou" they are called by French Canadians, and, as the term implies, they are flabby and tasteless; but in northern lakes and streams they are firmer and sweeter than in eastern and southern regions. In waters connected with the Hudson Bay basin I have found them firm, white, and so well flavored as to compare favorably with any other table fish. One species, the large Channel Cat (*Ictalurus punctatus*), is worthy of special mention both for its fine edible qualities, and for the sport it furnishes. It is a strong, powerful fish when hooked; but it is voracious, and like the whole Catfish family, something of a scavenger.

BLACK BASS IN IRRIGATION RESERVOIRS.

The black bass, when planted, may cause disappointment, because of its inordinate voracity. It will devour its own young if other small fish are not plentiful for food. Where few bass could find sustenance a far greater number of yellow perch would flourish. Black bass, of both species, nest in shallow water—three to six feet deep—and shelves of concrete, or of sunken wood covered with gravel would be necessary as nesting platforms. Even yellow perch increase more favorably when such platforms are provided, but they must slope from two to four feet, and freezing in early spring, when the water may be low, is thus guarded against. Pike perch or wall-eye pike are fine fish, but must have shallow gravel areas, over which running water passes to produce the best results.

VARIOUS FORMS OF SCREENS FOR IRRIGATION DITCHES.

Screens at the intake or inlet of all ditches and canals are really essential, especially if there is any communication with streams frequented by trout, as in the eastern foothills of the Rockies. The complaint of a Canadian Fishery officer that "irrigation ditches are great cause of destruction. . . . but screening is possible if properly done," (Canadian Alberta Commission report 1910-11 p. 960) is a common one, though the red-throat or cut-throat trout, if of any size, rarely perish; but pike and bull trout (*Salvelinus malma*) commonly do so, as well as many small species of fish of little value.

"I never saw trout in irrigation ditches, or trapped in pools

overflowed," is the statement of an experienced western man .... "I have seen suckers and grayling (Williamson's whitefish); but trout are too smart, and are never taken in irrigation ditches" (Ibid p. 101). A well-known ranchman in Western Alberta declared: "There should be screens at the headgates. They would not clog as there is not enough rubbish to cause much bother." (Ibid, p. 99).

Twenty-five years ago the State of Maine tried to enforce a law requiring screens to be installed at the outlets of all lakes and ponds (See *N. Y. Fishing Gazette,* June 25, 1897). The amount of leaves and rootlets floating in the water varies in different localities; but the device invented by State Warden W. F. Scott (Montana), and described in *Forest and Stream,* February 14, 1903, meets the most serious objections. It is simply an eight-bladed paddle-wheel, placed in a short flume at the head of the ditch, the projecting end of the center octagon shaft working in a slot-bearing at each side. If very wide, two flumes are advisable, and they so work that any large materials or hard substances pass under the paddles because the whole wheel rises, the axle being lifted up in the vertical slot at each side. Frightened away, it is claimed, by the splashing of the paddle blades, fish remain at the upper side of the device at the head of the ditch. A modification of this paddle device has been suggested, viz., a barrel-shaped frame covered with small-meshed wire netting, and fitting the flume closely. I think it was Dr. Henshall who proposed the barrel screen, and the use of the paddle for motor-power. If the pulley be placed on the projecting shafts outside the flume, and the belts crossed, then the paddles work in a direction opposite to that of the barrel screen at the entrance to the ditch. By this arrangement the device is self-cleaning, all leaves and rubbish being carried over, and the fish prevented from finding a passage down. In very wide ditches two flumes and a double apparatus are advisable.

A patent screen, invented by Mr. W. Parsons (U. S. Patent 1166628) resembles the Scott device; but the patent of Mr. Dreher, Detroit, Mich., (U. S. Patent 1150348) is provided with a paddle bearing long prongs to deter the approach of the fish. A more elaborate device is that of Mr. H. Broberg (U. S. Patent 1147301) which rotates on a vertical not a horizontal shaft, and

its inventor has claimed that fish are deterred from passing down and it cannot be clogged by floating rubbish.

CONCLUSION.

It appears far from chimerical to assert that large canals and reservoirs, constructed for supplying water for irrigation, offer great possibilities for fish culture, if suitable species of fish be used for stocking, and if spawning shallows be provided, and the fry after hatching be prevented from escaping into the ditches and laterals.

Great facilities are being provided in dry belts of the country, where native fish are usually scarce, for creating fish reserves and establishing a fish-supply for sport, or even for commercial purposes, and of guarding against the destruction of the fish already occurring in the local lakes and streams.

POLLUTION OF INLAND STREAMS.

By M. D. HART
Richmond, Virginia

History teaches us that the march of civilization has found and always will find man encroaching upon the habitats of our wild life, and in using the land and water for human necessities, wild life must gradually yield its domain. The task ahead of the wild life conservationists is not to undertake to arrest the laws governing human progress, but rather to direct man's course so as to conserve as much as possible for his use natural resources of immense importance to him economically and recreationally.

There is not a wild life conservationist who does not subscribe to these fundamentals. The game departments of every state in the Union trace their creation back to the efforts of the men who hunted and fished, and any state game and fish department which fails to realize its source of power and which does not lend a sympathetic ear to the hunters and anglers within its confines is doomed sooner or later to perish. So the leaders in this great cause should take these men absolutely into their confidence, and though we may now and then be forced to take certain positions seemingly antagonistic to the interests of hunters and anglers on account of the far-reaching future consequences we can foresee, minute and thorough explanations should be made publicly.

The subject of stream pollution is a burning issue in every eastern state. The habitats of the fish, like those of the big game of America, are being taken up for man's use. The fish will have to give way like the bison, the elk, the moose and the antelope. At the sessions of the general assembly of every state in the east it is the rule rather than the exception to find proposed drastic pollution laws submitted for enactment. Heading and pushing these measures are to be found enthusiastic anglers; opposed to them, the various enterprises polluting the streams and destroying the fish life—recreational interests versus money interests. We state game department officials naturally are aligned solidly behind the interests given to our keeping. We appear before legislative committees and lay down the great, fundamental principles that

no man or set of men have any moral right to contaminate a natural resource such as water belonging to all of the people any more than they have a right to contaminate the air; that no man or set of men, by the same token, have the right to use the water unless they return it to its natural beds or channels in the same purity as when taken by them. But we get nowhere, because we assume to lead in these fights when the primary interests, such as the state departments of health and the state departments of agriculture, should be in the vanguard and we poor little Isaak Waltons in the rear guard and commissary department. You might just as well put a six-year old boy in the ring with Dempsey and expect him to win as to pit all the anglers in any state against all the millions commandeered by these polluting industries.

I am fundamentally against unnecessary pollution. I am fundamentally in favor of manufacturing industries and the use of certain water courses by them, the damaging refuse to be cared for where possible. Otherwise, to my mind, the feasible solution is to have surveys made of the streams in each state, setting aside certain of them for industrial enterprises and certain of them for recreational purposes. Thus the angler will not be denied his health-giving outings, and on the other hand your industrial enterprises will be relieved of that constant fear that they will be put out of business by some legislative act.

I do not know that anybody ever suggested this plan before. I am satisfied that in some of our eastern states it would not work; for in some of them nearly every stream is polluted. But there are states—Virginia, for instance—which have some open streams, and it is just a question of time when something will be done which will result in their being polluted. The scheme, therefore, should receive consideration where pollution has not found its way into every stream of a state.

I feel, too, that the matter of publicity regarding pollution has not been handled as it might have been. If you ask the average man you meet in the country—or in the city, for that matter—what his opinion is as to how long it will take water to clear itself, he is apt to say it will do so within a distance of twenty miles everytime. We know that that depends on the kind of pollution, the amount of pollution, the rapidity with which the water is running, and so on. In fact, in the case of some kinds of pollution the water never gets clear. Now, I have been in several aquaria. I

have been in the aquarium at Washington, which is a splendid one. This thought suggests itself to me: that you put a sign up in the aquarium stating that this kind of game fish can be reared in certain waters provided that the water is not polluted. Before the Virginia Game Department was established the United States Bureau of Fisheries did not send us many fish because they thought that we in Virginia did not protect the fish. We are getting our share now. I feel satisfied that sometimes they have not sent fish to Virginia because those fish were requested for certain rivers that the Bureau was satisfied were polluted.

You gentlemen who are doing so much for the anglers and to whom the anglers are so much indebted for the scientific work that you are accomplishing, ought to pay some attention to the pollution end of it. The anglers do not seem to organize as the hunters do; the hunters are the men who get legislation, and anglers for the most part come to us when they want anything of that kind. If we will interest the state health departments and the departments of agriculture in this pollution business, I believe we can secure legislation; but until we do we are not going to get anywhere.

As to the nature of the pollution, or trade waste in our inland streams of which I am speaking, it is at one place, for instance, a sulphite that is doing most of the damage. Our state has taken action to prohibit these mills from emptying their trade waste into our streams, but we have never got anywhere. We have a law prohibiting any man from putting any noxious or deleterious substances into a watercourse whereby the fish therein may be destroyed. But when you take a case into court you have got to have the fish there and you have got to prove that that fish was destroyed by the pollution of which you are complaining. We may have three or four saw-mills on a river where the sawdust is killing the fish. We may produce evidence to show that the fish are being affected by sawdust in the gills, but then we have to prove that the particular saw-mill we are after put that sawdust in the river; and when it comes to a criminal action of that kind—well, you simply cannot do it.

Discussion.

MR. A. L. MILLETT, Boston, Mass.: I find myself in accord with Mr. Hart's ideas as to publicity being one of the best weapons to combat this menace of pollution. I also feel that if you are going to discuss pollution you should not confine it to the streams. The states have control also of the coastal waters, and there you find the greatest of all pollution, that of

oil. Furthermore, it is useless for us to discuss this pollution matter unless we take into our confidence or into our conferences the business men and those whose interests would be affected by any legislation that might have the effect of hampering or wiping out certain industries. We know that you cannot combat big business when it is established three or four miles on each side of a river. It is of no use for us to think that we can put that business out of the way for the sake of a few fish; it simply cannot be done, and it would not be good judgment to try it. But as Mr. Hart says, there are many streams that have not been encroached upon and which we could control or hold forever for the use of the angler.

Mr. Hart: When we were presenting that pollution bill, fashioned closely after the New York and New Jersey laws, at the last session of the state legislature, we sent for Mr. J. W. Titcomb; we anglers and sportsmen thought that his testimony before the committee would be such that we would not have much trouble getting the bill through. Mr. Titcomb is a fair and square man; he told the legislative committee considering the bill that neither the State of New York, the State of New Jersey nor any of the other states, were enforcing their pollution laws strictly, for the simple reason that they had too much business sense to put industrial enterprises out of business. I would like Mr. Titcomb to tell us what he said down there.

Mr. J. W. Titcomb, Hartford, Conn.: I explained the general effects of pollution—its destructiveness to oxygen and its effect on the growth of vegetation, and all that sort of thing that everybody is familiar with. I am not a pollution expert, but I made some general remarks along that line to help Mr. Hart with his bill. I told Mr. Hart beforehand I was sorry that they had introduced a bill which it would be impossible to enforce without killing industry. When I finished, members of the committee questioned me, asking if there was any solution for the problems presented by certain pollutions such as the discharge from dye factories, from sulphide pulp plants, and so on; and I had to confess that we had no solution. It seems to me that all our work in connection with the purification of our waters must be devoted to a study of the problems involved and of methods of taking care of the wastes which cause pollution.

Mr. Hart: I do not want you gentlemen to think that I oppose in any way the development of processes to take care of pollutions. I understand that Germany has made more progress in this line than most other countries; and I hope our scientists and experimenters will continue that work. I do not doubt that from the economic standpoint you have streams that it would be better to turn over to your industrial enterprises; on the other hand, I do believe that the anglers of the state have some rights. We have started out on a proposition now looking to the establishment of public shooting grounds. Why are we doing that? Because practically all the land has been taken up and the hunter who does not belong to a club has been shut off. Well, if you do not take steps to protect your watercourses, or some of them, for the anglers, you will find yourselves in a situation similar to

that which now prevails in respect to hunting. It may be many years; it may be twenty-five, fifty, or one hundred years from now, but if something is not done you will eventually be faced with the same conditions that we are facing down there in the east.

THE MASKINONGE: A QUESTION OF PRIORITY IN NOMENCLATURE.

By E. T. D. CHAMBERS

Quebec, Canada

One of the most prominent members of the American Fisheries Society, the learned Doctor Prince, of Ottawa, in a paper published by the Dominion Government, some years ago, on "The Vernacular Names of Fishes," furnished some interesting illustrations of the diversity of names applied by different people to the same fish. In the course of his article, he said:

> As a rule these early names—Indian or Indio-French names, which the early settlers continued to apply to animals, because they were already in use—always more or less accurately describe features in the forms on which they were bestowed. Thus the name maskinongé, commonly, but very erroneously, spelt muskellunge or mascalonge in the United States, is really an Indian name, the Chippewa name for pike being kenosha and the prefix mis or mas means large or great, so that maskenosha or maskinoge (corrupted into maskinongé) is really a large, deformed pike.

In the case of *Esox nobilior,* or Lucius masquinongy, whose popular title in its original form, like that of the ouananiche, comes down to us, as correctly claimed by the late Fred Mather, from its Indian nomenclature, an apparent desire to get away from French orthography has produced a somewhat similar confusion of language to that which so long existed in the case of the ouananiche. The original spelling of the Indian name was undoubtedly "maskinongé," and such it is officially called in the statutes of Canada, in which country the fish was first known and the name originated. According to Bishop Lafleche, who was a recognized authority upon Indian customs and dialects, and in his early life a devoted missionary to the Northwest, "maskinongé" is derived from mashk (deformed) and kinonjé (a pike), and was applied to the *Esox nobilior* by the Indians, because it appeared to them a deformed or different kind of pike from that to which they had been accustomed. The river of the same name that flows into Lake St. Peter, which name has been extended to the town built at its mouth, and to the county of which it is the chief place, was so called from the number of these fish taken in or near its estuary, and after their Indian name. And it is a singular corroboration of the abso-

lute correctness of the French orthography "maskinongé," that no less an authority than Dr. James A. Henshall, the author of the paper on this fish in "American Game Fishes," following the nomenclature of Dr. Mitchell, as quoted by De Kay in his "Fishes of New York," substitutes for *nobilior,* as the scientific name of this particular species, masquinongy, which is about as near as it is possible for English orthography to go in representing the correct pronunciation of "maskinongé." Yet Dr. Henshall claims that by common consent and custom the name is "mascalonge" among the majority of anglers and that "mascalonge" it will be for generations to come. Nor does this mongrel name represent the full extent of the departure from the original name. Dr. Henshall mentions, among other forms, "muscalonge," "muskellunge," "muskallonge," etc., and a variety of other spellings has been adopted by other writers. "Muskellunge"—one of the forms already quoted is the name employed to designate the species by Dr. G. Brown Goode, in his "American Fishes," and is as far removed from the original name as "winninish" is from "ouananiche." It may take some time to arrive at uniformity in the spelling of *Esox nobilior's* familiar name, but it is encouraging to note the general conformity, in recent years, to the name "ouananiche," which is the statutory designation in the country in which that fish is found, and it may be useful to point out that "maskinongé" is also the statutory form of the name of another Canadian fish, and, like "ouananiche," has in its favor the undoubted claim of priority of nomenclature.

Dr. Tarleton H. Bean has declared in a contribution to "The Encyclopedia of Sport" that the priority of the Indian word "maskinongé" is well supported. Dr. Gunther, a fellow of the Royal Society, and for many years keeper of the Zoological Department of the British Museum, avoids altogether the word "mascalonge" in his voluminous "Introduction to the Study of Fishes," and describes the fish as "muskellunge" of "maskinongé."

That splendid American sportsman and angling author, Mr. Genio C. Scott, admirably summed up many years ago some of the reasons which compelled his use and advocacy of the orthography maskinongé. In his "Fishing in American Waters," he says:

The Ojibwa name of this fish is "maskanonja," meaning long snout. When Canada was a French colony the habitants named it masque-longue, signifying long visage I submit that the Ojibwa was entitled by priority to the right of naming the fish; but, as the Dominion of Canada has named

it again, and in all legal enactments where there is reference to it the name of the fish is writtn maskinongé, I willingly accpt the modification instead of either the Indian or the French name. Thus much in explanation of naming a fish which has puzzled most ichthyologists and anglers, so that they have been uncertain and dubious on the point. The name is maskinongé.

And to emphasize his concluding statement, Mr. Scott printed the name in small capitals.

I might continue to quote from other distinguished writers of fish and fishing, notably from Mr. Whitcher, from Mr. Wilmot, from L. Z. Joncas, from Professor Ramsay Wright, of the University of Toronto; from A. N. Montpetit, author of the exhaustive book entitled "Les Poissons d'eau douce du Canada"; from Castell Hopkins, in his "Cyclopedia of Canada"; from Sir James M. LeMoine, D. C. L., in "Les Pecheries du Canada," and from many more, did time and space permit; though I am satisfied that enough has been said to show that the employment of the form "mascalonge" is far from being as general as some suppose and that if uniformity of nomenclature is to be looked for in the case of the fish in question, with any prospect of success, it must be upon the basis of the name by which it has been officially known for considerably over half a century in the country in which it was first found and described by white men—which has received the general indorsement of writers upon fish and fishing—and which by Mr. Genio C. Scott, in 1849, and by the North American Fish and Game Protective Association in 1904, has been alike declared to be "maskinongé."

However, the Bard of Avon, whose frequent references to hook and line shows that he was quite as well up in angling as in botany, is authority for the statement that "a rose by any other name smells quite as sweet," and no matter how we spell the name of the great game fish of the St. Lawrence, the angler who takes it with becoming tackle, will find that he has a foeman worthy of his steel.

This is not going to be a monograph on the maskinongé for there are already excellent ones in print, but you may be interested in a few captures of the fish that have occurred in recent years in some Canadian waters. There the favorite fishing grounds are in the St. Lawrence, a little below where the boundary line between Ontario and Quebec crosses the river. Other popular resorts of the fish are in the neighborhood of Vaudreuil and Isle Perrot,

which are only one hour's run by railway from Montreal on the roads leading to Ottawa.

Some time ago, a fourteen-year-old boy named Wanklyn was trolling near Isle Perrot from a boat in which were his father and sister. His bait was a perch nearly a pound in weight, the dorsal fin of which, with its sharp rays or spikes, had no terrors for the huge-throated fish which gorged himself with it and became impaled upon the hook. It may well be imagined that the boy had a swift time for half an hour or so with his new connection. When it was first found possible to bring the fish close up to the boat, Mr. Wanklyn struck at it with the gaff and impaled it at the first attempt. Its weight was such, however, that the effort to lift the fish into the boat tore the gaff out of its body, and a stream of blood marked its course as it writhed in the water, lashing it into foam and then placing a considerable distance between itself and the boat. It was not very long before it was again brought to the side of the boat, and the gaff having a better hold in the body of the fish this time, it was safely, though not without considerable difficulty, lifted over the stern of the boat. Even then it was not killed without considerable difficulty and some danger of upsetting the boat. The head of a maskinongé, when well mounted, as this one certainly is, makes a very handsome trophy.

A few years ago, the Ontario Department of Fisheries at Toronto received a magnificent specimen of maskinongé, over five feet long and weighing fifty-two pounds. It was caught in the branch of the Rideau River, which passes through Kemptville, by Sam J. Martin, of Kemptville. Big as this specimen was, it has been cast altogether in the shade by a capture by a French-Canadian, Mr. Alphonse Allard, at Chateauguay, on the border of the St. Lawrence, a little west of Montreal. This monster, which was sixty pounds in weight, had a girth of twenty-seven inches. The length of the head from the tip of the snout to the back of the gill was exactly a foot.

Most maskinongé are taken with hand line and trolling spoon, and hauled in hand over hand, so that the fish have no opportunity of displaying their game qualities. When, however, one fishes with an eight-ounce black bass rod and brings a St. Lawrence maskinongé of thirty-two pounds fairly to gaff on it in twenty minutes, as Dr. Henshall once did, he has certainly enjoyed twenty minutes of exciting sport, and has reason to be proud of his achievement.

On a taut line, the maskinongé often leaps clear of the water, and being a powerful fish, requires at this time very careful handling. The great difficulty, with light tackle, is to keep the maskinongé from running into and entangling himself in the weeds, rushes, or sunken tree tops in which he probably lay concealed when he rushed for the angler's bait. This cannot always be done, but there is sport in trying it and good assistance can be rendered the fisherman by his guide, who should know enough to pull for deep water immediately a fish is hooked. The rod should not be more than nine feet in length, and eleven or twelve ounces in weight, but the hook should be fastened to the line on a gimp snell, for the teeth of the fish render gut impossible of success.

Discussion.

Mr. G. C. Leach, Washington, D. C.: This matter of nomenclature in fish culture as applied to fish is a very important one. Some of our fishes in the United States that are known by certain names in the northern sections are entirely unknown, so far as those names are concerned, in southern sections. For instance, our trout in the northern sections are not so designated in the southern portions of the United States, but the bass down there are called trout. It would be a very good thing, both in the United States and in Canada, if we could have some uniformity of nomenclature. But I suppose, as Mr. Chambers explains, these names are handed down through different races—the Indians, the French Canadians and English—with the result that some differences creep in, and after a few generations the name becomes changed. I think Mr. Chambers' paper in a very interesting one and bears on a subject to which more attention ought to be paid.

Dr. E. E. Prince, Ottawa, Canada: The fact that we have had a paper like this, upon a literary phase of the fisheries, is an illustration of the variety of topics covered in the discussions and proceedings of the Society. I have great sympathy with Mr. Chambers' contention. He referred to an old official report of mine on "The Vernacular Names of Fishes," in which I showed how utterly hopeless it was to understand what we were talking about when we used popular names.

As Commissioner of Fisheries for Canada, almost every year I have this question put to me: What is a pike, and what is a pickerel? It is one of those questions almost impossible to answer, because you must first of all ask the questioner: What do you mean by a pike, and what do you mean by a pickerel? We in Canada use certain names in one sense, while in the United States they are used in another. I may say that eleven or twelve years ago Dr. David Starr Jordan and myself had the task assigned to us by our respective governments of drawing up international regulations for the contiguous waters of Canada and the United States. We decided upon a list of the names which we would use in our regulations, and when Dr. Jordan heard my arguments—which were very much the same as Mr.

Chambers has given us, though not quite, because Mr. Chambers has gone into the matter very much more thoroughly—he agreed that maskinongé was the correct name; and on behalf of the United States Dr. David Starr Jordan adopted that name in the international regulations.

The term "muskellunge," so far as I can see, originated through a mistake. Anglers who came into Canada from the United States found a fish called the "longe" or "lunge"—that is the big lake trout; and when the Indians and French-Canadians spoke of "maskinongé," by some means the visiting anglers confused "lunge" with "maskinongé"; and so we got this word "lunge" imported into the name of a fish that never in all its history was called "lunge." "Maskinongé" has a meaning; it describes the fish accurately; "muskellunge" means nothing and describes nothing. As Mr. Chambers has pointed out, it is a comparatively new name; it does not date back very far. The name "masquinongy" occurred in the Canadian Fisheries Act and has been there for at least fifty years. I would strongly urge the adoption of names which have an historical as well as a descriptive basis.

Mr. C. F. Culler, Winona, Minn.: I would like to know the difference between the northern pike and the maskinongé.

Dr. Prince: There are several differences. The northern pike has little spots of white spread out on a darker ground, whereas with the maskinongé there are darker marks on a pale greenish or brownish ground.

Mr. Chambers: As a rule the markings on the great northern pike, *Esox lucius,* are oblong in shape, a pale oblong spot; whereas the darker spots on the lighter ground in the maskinongé are very much smaller, rounder and darker. These, of course, are the body markings.

Mr. Leach: The markings are very apt to change according to the water in which they are found. In the St. Lawrence, where water is perhaps swifter and somewhat different in color from the water in some of the inland lakes of Wisconsin and Minnesota, the markings are apt to be different. That is true of almost any fish; the character of its food and environment also has an effect upon the markings. The State of New York a few years ago issued a little placard illustrating the different species of pike and gave a brief description of each, so that there would be no confusion between pike, pickerel, and pike perch.

Dr. Prince: Of course the scales on the cheek and operculum are quite different. On the cheek in the northern pike they pass all the way down; but half-way down on the gill cover; whereas in the great maskinonge they are cut off half-way down on both cheek and gill cover. The small chain or grass pike has scales all the way down on cheek and gill cover.

Mr. E. W. Cobb, St. Paul, Minn.: Do I understand, Dr. Prince, that you consider the great northern pike to be the same fish that we call the pickerel—*Esox lucius?*

Dr. Prince: Yes; that is what is called pickerel in most of the states.

Mr. E. W. Cobb: And that the "muskellunge" is distinguished by the scales being on the upper part of the cheek and gill covers only; that is correct, is it?

DR. PRINCE: Yes. At the same time, there are several species of the jackfish or northern pike. There is the big northern fish, *Esox lucius*, and there are a number of other varieties. You would never confuse these with the maskinongé, which is really a very large fish; it runs to a considerable size.

MR. E. W. COBB: In Becker County, Minnesota, we have a fish that some call pickerel and others that are called northern pike. They are distinguished by the difference in size; there is also an oblong, light-colored spot which indicates the pickerel. You will find them with that identical cheek and gill-cover marking, following back from the eye. But the whole thing is very confusing to us.

DR. PRINCE: The publication referred to by Mr. Leach makes that plain; every species is described so that confusion can be avoided.

MR. E. W. COBB: I have that; but on this fish I found the identical scale marking that he finds on the "muskellunge." I could not convince anybody up there that these fish were "muskellunge," because they have identically the same markings as the pickerel, and are the same shape.

DR. PRINCE: Maskinongé is not a fish that is thought to extend to the far west, though a letter has recently reached me from a correspondent who claims that it occurs in South Saskatchewan.

MR. E. W. COBB: We have what we call the "muskellunge" in the upper Mississippi—a somewhat darker fish with dark bands. It is a very beautiful fish. Its coloration is hard to describe, but when it comes out of the water it shows a brilliant golden color as though it were draped over with something like glistening sheen, showing underneath a sort of changeable glistening hue. Some of them weigh 30 to 35 pounds.

MR. CHAMBERS: I have some sympathy with the use of the name "pickerel" for "pike," because I remember that in England the small pike are called pickerel. But unfortunately, in Canada, and I suppose also in some parts of the northern states, the name "pickerel" has been applied erroneously to the pike perch, or the doré, as it is known to French-Canadians.

THE BIOLOGICAL SIGNIFICANCE OF THE SMOLT PERIOD IN CERTAIN SALMONOIDS

By William M. Keil
Tuxedo Park, N. Y.

In a paper read before this Society at the last meeting, the writer made the following statement: "If good results are to be expected from the planting of landlocked salmon and steelhead trout in lakes containing no permanent tributary streams, the fish must not be turned out into such waters until they have passed the parr stage and begun to take on the silvery coloration of the smolt." Such a statement *needs* substantiation, and the purpose of this paper is to present to the Society the results of over twelve years of experimental investigation of this subject. Preliminary to this it will be necessary to give a brief outline of the stocking operations that were instrumental in bringing about this study.

There is probably no other angling water in the world where the results from planting salmon and steelhead have been so carefully recorded as at Tuxedo Lake. For over twenty-five years an accurate record has been kept of not only the number and size of the fish planted, but the number, size and condition of those taken by anglers as well. During the years from 1900 to 1906, both of the above varities were planted either as nineteen-months-old fish in the fall or two-year-olds in the spring, and the fishing registers at the boat houses show that approximately 50 per cent of the numbers turned out were retaken by anglers. This lake also contains great quantities of bass, perch and pickerel, and the good results secured by this method of stocking was at that time attributed entirely to the size of the fish planted. While thousands of good-sized fish of the two kinds were taken by anglers each season, the salmon especially, were not in the best of condition, and the club fish committee was informed that in all probability these fish were being stunted by being retained too long in the hatchery pools. Several well known authorities advised the planting of fingerlings, and as an experiment, the committee decided to turn out great quantities of these, rather than a smaller number of the older fish. The hatchery was given instructions to put out

everything as fingerlings in the fall, and for three years following, an average of 200,000 were planted each October.

This change of method in stocking had a very noticeable effect on the fishing within a year's time. The catch of salmon and steelheads dropped from 3,100 the preceding year, to 1,644 the following season. No small fish were taken by the anglers; but for the first season at least, it was thought that the fingerlings had not grown to a size where they would take the lure. The records for the next two years tell the whole story; 786 fish were taken in 1908, and but 30 in 1909, with no immature specimens taken by angling or observed around the mouths of the brooks or elsewhere in the lake. Previously, many small male steelheads would be taken in the collection of breeding fish in the small tributary streams during the spring freshets. It must be kept in mind that this lake, like hundreds of others in which salmon and trout are planted, is fed principally by springs; and that the few small brooks that empty into it are dry by the middle of summer and usually remain so until the late fall or winter. Had there been permanent tributary streams in which to plant these fingerlings, the results no doubt would have been entirely different.

Of the lot of fingerlings reared during the summer of 1909, 15,000 of the largest were sorted out, pushed ahead as rapidly as possible, and 5,000 planted as 6 and 7-inch yearlings in May, 1910. The remainder of the lot were carried through, for it had been decided to resume the planting of older fish. Careful observation of the movements of these yearlings after they were turned out, disclosed the fact that instead of separating and going out into deep water as was the habit of the two-year-olds, they remained together in schools, swimming around near the shore and congregating at the mouths of the brooks at such times as these streams were influenced by heavy rainfall. As the surface water grew warmer toward the middle of summer, they gradually disappeared, and it was thought they had gone down into the deep, cold water of the bottom. None of them were taken by angling that summer or fall, nor was there any evidence the following season to show that any had survived. The yearlings that had been carried through (4,900 steelheads and 3,114 salmon) were planted in November, 1910, averaging about 9 inches in length. The summer of 1911, several hundred of these were taken running from a pound to a pound and a half in weight. By the fall of 1911, the hatchery was so

regulated that approximately 6,000 of 8 to 10-inch fish could be planted each season, and the records of 1912 show the catch coming back to normal with 2,200 taken, averaging 2 pounds.

It is not the intention in this paper to enter the controversy that has arisen between fish-cultural workers over the relative value for stocking purposes of fry, fingerlings, or yearlings; but rather to point out that with fishes of these varieties, nature has shown us in an unmistakable manner the time at which they should be turned out into the open waters of lakes. It was while the fingerlings were being planted and producing no results, that the writer first began to doubt the prevailing belief that their disappearance was due to predatory fish. It did not seem credible that all of them should be eaten up however numerous the bass and pickerel. This opinion was further strengthened by the peculiar actions of the year-old fish that were planted, and by their disappearance also. Why should 19-months-old fish of 8 and 9 inches produce good results, and 12-months-old ones of 6 and 7, none at all?

During the summers of 1910 and 1911, the writer visited a number of waters in New England where landlocked salmon were being planted as advanced fry and fingerlings. In every instance where good fishing had followed the planting of salmon in these stages, it was found that the lakes either had good sized streams emptying in them, or a considerable permanent overflow at the outlet. At most of these places, while it was reported that the fish had been planted directly into the lake, hundreds of small salmon in both the fingerling and yearling ages were observed in the streams tributary to or flowing from such lakes. One of the finest locations for a study of these conditions was found at the Averill Lakes in northern Vermont. These two lakes, which furnish angling not to be excelled elsewhere in New England, are connected by a stream of about a mile in length. Little Averill—the upper lake, is fed by springs and by a small tributary inlet at the northern end. In both this inlet and the connecting stream between the upper and lower lakes, many hundreds of salmon parrs could be seen and readily taken by means of net or minnow trap. They were of both the first and second summer's growth, with the bars and red-spot markings very conspicuous. The length was from 1½ to 5 inches, and during three weeks of observation in July, no examples were taken showing the least signs of assuming

the smolt coloration. One of the local guides who had promised to send certain information, reported that fall that the larger of these fish had turned silvery and was beginning to move out of the streams.

In order to determine the average age or size at which this color transition takes place, in both salmon and trout of a migratory type, five seasons were spent in gathering data for comparison. This was necessary on account of the great variation in incubation and growth during different seasons and at various localities. From observations upon thousands of specimens of known age, it was definitely established that with fish of normal growth, this change from parr to smolt begins during the latter part of the second year.

All writers handling the subject of the life history of the Atlantic salmon, while briefly mentioning the remarkable color-change of the young fish previous to migration, studiously avoid commenting on the probable significance of this change. No doubt it would be regarded as an adopted protective coloration, were it not for the fact that it takes place before rather than after migration. This change of the trout-like parr to the silvery smolt, is not one of color alone, for there are several anatomical changes as well. During this stage, the form, fins, and especially the tail, take on certain characteristics of the adult fish; while the sexual organs, as if in preparation for functioning, undergo their first real period of development. The silvery, metallic-like appearance at this time is not caused by the formation of new scales, but by the depositing of a pearly pigment over the sides and gill-covers of the fish. This, in the opinion of the writer, is nature's method of armor plating that portion of the body containing the thousands of tiny ducts, whose functions would be impaired or destroyed by the tremendous water-pressure of lake or ocean. It was with this idea in mind that the following experiments were carried out, which resulted in evidence so definite in character that they may be regarded as having solved the entire problem.

These experimental tests were carried out to determine what effect or influence the water-pressure had on landlocked salmon and steelheads in the various stages from advanced fry to 2-year-olds. In order that the results might not be influenced by factors other than water-pressure, the experiments were conducted at such times as the water temperature and dissolved gases were uniform

from surface to bottom. Those members of the American Fisheries Society who are familiar with limnological work, and with the extremely short periods during the spring and fall, when such conditions are found, can understand the length of time required to carry out these tests. In each experiment the apparatus and methods of procedure were the same. A wire cage containing the fish was attached to a measuring line and lowered 6 inches at intervals of one minute each. At every 5-foot mark the cage was raised, at the same degree of speed, to the surface for observation.

No. 1. April 12, 1914.—Six landlocked salmon, advanced-fry (feeding two weeks) returned from 5-foot depth in uneasy condition; from 10 feet, all dead.

No. 2. April 12, 1914.—Six 10-months-old steelhead; 5 feet, no change; 10 feet, all distressed, three had changed to pale color; 15 feet, five dead with one in very feeble condition, which upon being returned to hatchery died later.

No. 3. April 13, 1914.—Four yearling salmon and four 22-months-old steelhead; 5 feet, no change; 10 feet, all salmon changed color; 15 feet, one salmon dead, others distressed; 20 feet, all salmon and one steelhead dead; remaining steelheads lowered to 55 feet with no bad effects except slight change in color. None of these steelheads died later in the hatchery.

No. 6. November 10, 1015.—Four 19-months-old salmon and four fingerling steelheads; 5 feet, no change; 10 feet, two steelheads dead, all uneasy; 15 feet, other steelheads dead; 20 feet, two salmon distressed, others normal; 25 feet, one salmon dead; from 30-foot depth to 55 feet, no change, and two salmon in normal condition and one distressed were returned to hatchery. None died later.

No. 12. November 14, 1915.—Six fingerling salmon, all died between the 10 and 15-foot depths.

No. 21. March 27, 1916.—One 2-year-old salmon with smolt coloration and one 20-months-old steelhead with partial smolt development were lowered to 60 feet without visible ill effects.

No. 24. April 3, 1917.—Two precociously-developed yearling salmon of 6 and 6½ inches, with indications of abnormally early smolt development, were killed between the 20 and 25-foot depths.

No. 25. April 4, 1917.—Two 2-year-old salmon, which still retained the parr markings, although the spots had faded to a faint orange. One died at 40 feet, the other remained normal.

No. 29. April 11, 1921.—At Sterling Lake, N. Y., two 2-year-old salmon and two steelheads 22-months-old, as fully developed smolts, were lowered to a depth of 110 feet without ill effect or noticeable change in color.

The above tests were taken from a list of fifty-four, which were brought to a conclusion in November, 1921. Many of them were in duplicate and were made in order to confirm former results and for the purpose of post-mortuary examination with micro-

scope. Such examinations disclosed many unusual organic disturbances and lesions. The most important one in respect to the subject under investigation was the peculiar distorted condition of the lateral-line canals; and it is believed that the inability of the parrs to withstand a high pressure was due to the unprotected nature of these ducts at this stage of their development.

These experiments, observations, and stocking experiences, have given us a number of clearly established facts upon which to exercise our common sense; and it should not be at all difficult to understand what has happened to millions of our landlocked salmon, steelhead and rainbow trout. Such fish planted while in the parr stages in spring-fed lakes without tributary streams, are unquestionably thrown away. Unable to find streams where nature intended them to be at this age, or to descend to depths in the lake where suitable food and temperature are to be found, these fish swim aimlessly around in the surface water and eventually disappear from one cause to another.

BRIEF NOTES ON FISH CULTURE IN MICHIGAN.

By Dwight Lydell

State Fish Culturist, Comstock Park, Mich.

This is to be but a very brief outline of two or three points in extension of the paper which I presented at the meeting of the Society at Ottawa, in 1920, under the title, "Progress in Practical Fish Culture." It has occurred to me as of possible interest to direct attention to the marked expansion of fish-cultural work now going on in the State of Michigan. As a result of these efforts the state will, it is believed, equal the efforts in any other state in the production and distribution of food and game fishes. We are building a number of new fish hatcheries and these, together with the ones already in use, will give a total of 16 plants. Their locations and the species propagated are as follows: Detroit, perch and wall-eyed pike; Drayton Plains, perch, bluegills, and large-mouth bass; Hastings, bass, perch and bluegills; Mill Creek Station, perch, bluegills, bass, wall-eyed pike and trout; Paris, trout; Harriette, trout; Grayling, trout; Sidnaw, trout; Sault Ste. Marie, trout; Harrisville, trout and bass; Wolverine, trout; Oden, trout; Thompson, trout, bass, perch and bluegills; Marquette, trout; Watersmeet, trout; and Benton Harbor, perch, bass, bluegills and trout.

We are making preparations to handle at least 25,000,000 brook trout each year, and at least 8,000,000 of these will be raised to fingerlings or past the fry stage. One of the important reasons why this is being done is because of the fact that in the spring the condition of the roads and of weather makes it almost impossible to plant fry in some of our northern waters, especially in those of the upper Peninsula.

Further attention is called to propagating bluegills, which matter was also referred to in the article presented in 1920. There have been some developments since which may be of interest. In preparing the rearing ponds they are drawn dry in the fall and left dry until well frozen out. In some cases they are left dry all winter. In the spring they are generally fertilized, if necessary, and then a small flow of water is turned on to let the temperature increase gradually. Water fleas soon become very numerous and that is about the time we introduce our bluegills.

Since our experience of two years ago, instead of using cheese cloth frames around the margin of the pond we now use any pan or box partially filled with sand. This is placed in the pond and the bluegills are deposited therein. They will rise three or four times and settle back; when they rise finally they swim away. Food is so plentiful in the pond that they get all they want until they are about three-fourths of an inch in length, when they will begin to come ashore; then we start feeding them. They will come from all sections of the pond; you can see thousands of them coming to get the food.

Anyone having in mind to take up this work will find it very interesting indeed. There is a great demand for bluegills in Michigan, especially in the southern part of the state.

Discussion.

MR. G. C. LEACH, Washington, D. C.: I would like to ask Mr. Lydell if he ever tried to take bass eggs off the nest with a glass tube and hatch them?

MR. LYDELL: Yes, we took some small-mouth bass eggs in that way and had a 75 per cent hatch. But it is not practicable. You can go on our rivers and lakes where they are spawning, and at the right stage, when the little fish are turning from the transparent stage to the black stage you can get them with a tube and put them in your ponds and raise them. But we have not had a chance to do that where we are; there are no nearby streams to make it possible. Moreover, it is not as sure as the bluegill work, because most of our small-mouth bass are in the rivers and if the least bit of a freshet occurs you cannot see the nest. In the lakes, however, where the bluegils are, you can keep them under observation from time to time until they had reached the stage that you are waiting for. One season's experiment will determine where they are. The tubes used were one-half inch in diameter and 30 inches long. We feed clam meal and also use it as fertilizer. Before the water is put in we sow about 100 pounds to a pond 300 feet long and 100 feet wide.

MR. C. O. HAYFORD, Hackettstown, N. J.: Do I understand Mr. Leach to ask if we take bass eggs off the nest and hatch them? We had three or four pairs of bass spawn before we moved them from the wintering ponds to the spawning ponds. When we drew these ponds to take the adult bass out there were three or four nests of small-mouth eggs. We rinsed the eggs off the stones into ordinary dish pans, then placed them in a Chase hatching jar. We followed the same process as in the case of hatching pike perch eggs, and a large percentage of them hatched. It has occurred to me that we might do some work of that kind in removing eggs from the reservoirs or streams. To what extent it could be carried on I do not know. When the eggs were removed from the nest the embryo was just beginning to show a little under the microscope. They developed more slowly in the jars.

FISH-CULTURAL WORK OF THE BUREAU OF FISHERIES IN THE MISSISSIPPI VALLEY.

By C. F. Culler

U. S. Bureau of Fisheries, Homer, Minn.

The work of the United States Bureau of Fisheries in the Mississippi River Valley consists of the reclamation from overflowed lands of stranded food and game fishes, or "rescue work" as it is more commonly known, mussel infection operations, and the propagation of cold and warm water fishes. Also scientific work is conducted at the Biological Station at Fairport, Iowa. All of these operations are carried on in the immediate vicinity of the Mississippi River. Fish cultural activities are also conducted at the Bureau's stations at Manchester, Iowa, where rainbow and brook trout, black bass and rock bass are handled; at Neosho, Mo., where the same species are handled; at Mammoth Springs, Ark., where small-mouth bass and crappie are handled; and at Tupelo, Miss., where black bass, crappie, and sunfish are propagated. But it is felt that no branch of the Bureau's fish-cultural work has attained more rapid development during the past few years than the Mississippi River rescue operations, the development and growth of which is manifested not only by the ever-increasing numbers of food and game fishes saved each season, but is also marked by decreasing cost of production.

Normally, the Mississippi River is a wide shallow stream flowing peacefully within its banks; but in the spring its waters are much swollen, due to melting snow and spring rains, and many thousands of acres of bottom lands and islands along its course are inundated. All through these lowlands are numerous lakes, sloughs, and small ponds, which during the low water are entirely cut off from the main channel and which are ideal spawning and feeding grounds for various species of fish. This is the greatest natural spawning ground of warm water fishes in the United States. The eggs are laid under conditions favorable to their development and the young fish attain a rapid growth before the freshets begin to subside. At this time a majority of the adult fish find their way to safety in the main channel, but the young

do not react promptly to the falling waters and enormous numbers are cut off and become permanently landlocked.

The lakes and sloughs left by the falling waters are of various sizes and depths; some of them dry up in a few days or weeks, while others become so shallow that the fish will freeze during the winter months. The shallower pools freeze solidly, while in the deeper ones the fish are so highly concentrated that death by smothering is inevitable, even though the pool does not freeze solid to the bottom. From these lakes and sloughs millions of fishes of all warm water species found in the Mississippi River are taken by the rescue crews and transferred to the main channel of the river or to a running slough, a small percentage being held for distribution to other waters.

The need of some sort of salvage work has long been recognized and the first attempts to save a few of the stranded fishes occurred in the late nineties. It is only in recent years, however, that the work may be considered as approaching a point commensurate with the need. In the past the lack of funds and trained personnel has worked a great disadvantage; however, Congress at the last session recognized the needs of the situation by providing a suitable personnel so that this important work can be further extended in the future.

The territory now covered extends from Prescott, Wis., on the north to Savanna, Ill., on the south; and the experimental work is being carried on in the vicinity of Rock Island to determine whether sufficient numbers of fish can be rescued at reasonable cost. Headquarters for the work are at Homer, Minn., with sub-stations at La Crosse, Wis., and Marquette and Bellevue, Iowa. These points represent the centers of the most prolific fields.

Some lakes and sloughs are not as productive as others, some having but a few thousand fish while others have large numbers. As an example of large numbers that are sometimes caught in one lake, the crew at Lynxville, Wis., seined a large shallow lake, the maximum depth of which was 28 inches, and carried 182 tubs of miscellaneous fish to the main channel. This represented a saving of 1,250,000 fish, or an average of approximately 7,000 per tub. These numbers seem large, but when it is taken into consideration that small carp an inch long will run approximately 1,200 per quart and small bullheads from 1,800 to 2,000 per quart,

it can readily be seen that the figures are not excessive. It will also give an idea as to the immensity of the work.

During the season of 1921, there were 178,100,161 miscellaneous fishes rescued and returned to the main river. Of these 506,394, or 29-100 of 1 per cent were shipped elsewhere to stock lakes and streams. The average cost in all fields in 1921 was 17.3 cents per thousand. When the work was first undertaken a number of years ago the cost was $3.18 per thousand.

Comparison of the cost of the rescue work with that at a station is clearly in favor of the former. The average cost of production of warm water fishes at a pond station is approximately $5.50 per thousand, while rescue operations have handled the same species at a cost of 13.5 cents per thousand, the cost varying with the price of supplies and labor conditions. If the fish rescued during the season of 1921 had been purchased from commercial dealers or reared at pond stations, the cost to the Bureau would have been approximately $979,550, while the actual cost, exclusive of the salaries of the regular employees, was $30,811. The comparison is obvious.

In connection with the rescue of stranded fishes, such species as are suitable hosts for larval mussels are infected with the glochidia and released; thus a double service is accomplished with only a slight increase in cost of the work as the same men perform both services.

The pearl button industry of this country is dependent on the mussels of the Mississippi River and its tributaries for raw material, hence keeping up the supply is of more than local importance. There is probably not a man, woman or child in the United States today on whose clothes there are not pearl buttons manufactured from Mississippi River mussels. There is no other known material as suitable for buttons of this type as the fresh water mussel.

In nature the mother mussel liberates the baby mussel when the gill pouches become filled with ripe mussels, and the little mussels pass out into the water with no known destination. If the proper fish, or host as it is known, happens to be swimming by, all well and good; the little fellow is carried on the gills as the fish breathes, and fastens there and stays until it has reached the stage when it can begin life on its own initiative. The length of time the larval mussel is carried on the gills of the fish is dependent on the temperature of the water. If no fish happens by when

the larval mussel is ejected from the gill pouch, it drops to the bottom and dies. It can be seen that nature is quite uncertain and haphazard in her method of reproduction of commercial mussels. By artificial propagation this can be remedied to a very great extent; nearly all species of game fish are suitable hosts for mussels in greatest demand by the pearl button manufacturers, and these fishes are infected with glochidia before they are liberated in the river. As showing the success of this work, the muckets in Lake Pepin have increased in the past six years from 28 per cent to 62 per cent. Also the yellow sand shell shows an appreciable increase on the lower Mississippi River and the White and Black Rivers in Arkansas.

Inasmuch as the fish taken from warm water during the rescue operations cannot safely stand a long railway journey, those intended for distribution are taken to the nearest holding station, where they are hardened for several days in cold running water. After this they are shipped by messenger or in the Bureau's distributing cars to all parts of the country. Fish have been sent to stock depleted waters in states as far east as Massachusetts, as far south as Alabama, to Arizona in the southwest, and to Montana in the northwest. In addition to its own distribution, the Bureau furnishes fish to the states bordering on the Mississippi River, where rescue operations are conducted. It is probable that many of these fish are planted in waters connected with the Mississippi River drainage system. Rainbow and brook trout are hatched and reared at La Crosse, Wisconsin, for distribution in the states in this section, with the idea of assisting the several states in keeping up the supply of these species.

At different points along the Upper Mississippi River eggs are taken, fertilized, and planted on the natural spawning grounds to aid in keeping up the supply of these valuable species of commercial fishes. The eggs taken in this manner would otherwise be an absolute loss, as they are from fish caught for the market. It is the intention of the Bureau to extend this work as far as available funds will allow.

In Louisiana the Bureau has been operating the only buffalofish hatchery in the country for the past four years. The hatchery is situated in the middle of the Atchafalaya Swamp, one of the greatest spawning grounds of buffalofish in the country. Appreciable results are shown in reports received from the Conservation

Commission of Louisiana telling of large quantities of undersized fish being caught in the sections where the greater portion of the buffalofish fry have been planted in the past. In the season of 1923 it is expected that a new buffalofish hatchery will be built on Bayou Plaquemine by the State of Louisiana in cooperation with the Bureau. These two hatcheries should do much to insure the future supply of buffalofish in Louisiana. The field employes working from the Atchafalaya Station have made minor investigations in regard to the spawning habits of the spoonbill catfish or paddlefish as it is known in some places. Very little is known of the life history of this species, and it is hoped to get some definite data another season.

The Bureau has also endeavored to cooperate with the several states in their propagation of all species of fishes and has at different times detailed experienced employes from the Fish Rescue Station to take charge of work in certain sections. As all are working to a common end, the spirit of cooperation that now exists between the several states on the Upper Mississippi River and the Bureau of Fisheries will mean increased activities and results that will be immeasurable.

The rescuing annually of millions of landlocked fishes, planting of hundreds of millions of commercial larval mussels on proper host fishes, the rearing of millions of commercial and game food fishes is surely indicative of the Bureau's usefulness in the Mississippi River Valley.

The Bureau's work in this field, especially the rescue work, is receiving each year more and more recognition from those interested in fisheries and conservation of the country's natural resources. Numerous letters are received urging the extension of this valuable work to new fields, but until Congress recognizes its importance by providing additional funds, new fields cannot be opened. The possibilities for the further extension of the Bureau's activities in rescue operations, mussel infection work, and propagation of commercial and game fishes are very great. The field is only partially covered, as there are many unbroken miles of river bottoms where no rescue work or mussel propagation has been done and many sections where the propagation of commercial fishes has not been conducted, that surely would produce good results if only funds were available. It is hoped that Congress will give special recognition to these needs.

The above-outlined fish-cultural operations, including rescue and mussel infection work, are of more than local interest. The food fishes of the Mississippi River Valley receive a wide distribution in the trade, while the number diverted for stocking other waters is of national importance. In fact, the importance of this fish-cultural and reclamation work as a means of increasing the food supply, furnishing sport for the angler, and maintaining the pearl button industry, can hardly be equalled in any other field, when cost, results, and quick returns are considered.

Discussion.

MR. E. W. COBB, St. Paul, Minn.: We have received each year consignments which we have taken out and distributed to applicants. Formerly we carried on rescue work down nearly to the Iowa line. To work over the same ground with the Bureau of Fisheries, of course, was useless duplication; so we took the territory north of Prescott, the Bureau working our side of the river south of Prescott; and they send us numbers of fish for distribution.

MR. G. C. LEACH, Washington, D. C.: In the past few years the various states along the upper Mississippi River have conceded to the Bureau the right to rescue fishes along the border waters of that river. Very amiable arrangements have been made, and I believe that they have been the means of increasing the efficiency of the work. In the early days the state legislatures did not seem to recognize the importance of the salvage of large numbers of food fishes. They would make a small appropriation and expect it to run over a period of two years. If it happened to be a very good year for the salvage of food fishes, the state would probably expend the fund in the first year; the next year they would have no funds and would appeal to the Bureau to take up the work. In view of these sporadic arrangements with regard to funds, it was found necessary for the Bureau to take over the major part of the work on a cooperative basis, and the states very generously assisted. We have, therefore, been working in close cooperation, and I think that is one reason why we have been able with our personnel to obtain greatly increased numbers of fish. The states are assisting to a considerable extent in the distribution of fish, receiving them at the Bureau's holding stations located at certain points along the river, and distributing them in their own waters. That is one thing that the Bureau has considerable difficulty in doing; the railroads in the states seem to recognize that the state should have certain concessions in regard to rates that they would not grant to the Federal Bureau.

MR. W. E. BARBER, Madison, Wis.: What proportion of the fish rescued are of the bass family?

MR. CULLER: Last year we rescued about 700,000 bass. The greatest number rescued were catfish, crappie, sunfish, carp, and buffalo. It might be interesting to refer to the sunfish. Four years ago, out of 34,000,000 fish rescued we handled only 600,000 sunfish; last year, out of 178,000,000

we handled 51,000,000 sunfish. There are points along the river where fishermen had not been catching sunfish and crappie for twenty years, but where this summer they were able to get the limit each day. Wabasha is one place; Fountain City, Lynxville and Marquette are others. Up to the first of September this year (1922) we had rescued and planted back in the river over 70,000,000 fish and about 145,000,000 larval mussels.

MR. J. W. TITCOMB, Hartford, Conn.: This is not exactly rescue work I am going to speak about, but it may be of interest to some of the commissions. In the State of Connecticut we have many lakes and ponds that are accessible to 20,000,000 people by driving 100 miles; in other words, a circle drawn around the center of the state takes in 20,000,000 people. Now, to keep these ponds and lakes supplied with the warm water fishes is quite a problem. The numerous cities in the state have water supplies which are mostly natural ponds and lakes; and as a sanitary precaution, it is unlawful to fish in them. This season we are getting concessions from the officials of these municipal reservoirs under which the Board of Fisheries is allowed to trap the fish in them and transfer the fish to the lakes and ponds which are open to public fishing. We argued that if we were allowed to net these reservoirs periodically for the purpose of stocking the public waters, anglers would not be tempted to fish them surreptitiously. The people who allowed us the privilege were authorized to post the lakes over the name of the State Board of Fisheries and Game; and we patrol the reservoirs so far as it appears to be necessary in order to safeguard them against pollution by poachers. The first reservoir yielded about 8,000 pounds of pickerel, bullheads and perch, consisting of fish ranging from one-half pound to five pounds in weight—a large proportion of them before they had spawned. Another lake yielded principally small-mouth bass. We got started only this spring, rather late in the season; but we now have concessions from the officials of five other cities, and some of these officials have charge of five or six reservoirs. It is a very interesting proposition, and I do not see why it should not work out in some other states. We have, in other words, a pond cultural proposition worth many millions, under which we can go and get our bass and other warm water fishes for the restocking of these much-fished ponds and lakes.

PROBLEMS OF THE COMMERCIAL FISHERIES FROM PRODUCER TO CONSUMER.

By J. H. Matthews

New York, N. Y.

It would be manifestly impossible to detail all the problems confronting the commercial salt water fisheries. Each branch of the industry has its own problems, which are seriously reflected in all other branches.

The problems of the producer begin to develop before he lands his first fish. A fisherman must first obtain his boats and equip them with the necessary nets, gear, bait, ice, etc. He must secure a license to operate his boats. He must have packages in which to ship his fish to market. Often he must employ extra labor in the handling of his production. It is often necessary for him to seek financial assistance to outfit his operations. Many times, his equipment and season's work are mortgaged far beyond their intrinsic worth. He sometimes spends days, even weeks, without taking enough fish to supply even his own family. When production becomes great and when he should receive the greatest returns for his labor and investments, he usually finds the market glutted and his returns probably no greater than a small percentage of his catch would bring if production was equal to demand.

There are times when he is made to suffer financial loss by unnecessary restrictive legislation. Many bills are presented in our legislatures, imposing prohibitory license fees and taxes on production, regulating the size mesh of nets and the length of seines, prohibiting fishing in certain areas, regulating the seasons when certain varieties may be taken, and various items in opposition to the needs and interests of the fisherman, and absolutely unessential to conservation. The fisherman's calling, though of equal importance, is more precarious than many other branches of industry. He should receive the same measure of support and encouragement as that now extended by the Government to other industries.

Many of the problems of production could be solved by the Federal Government with the cooperation of the various states and through appropriations for the Bureau of Fisheries large enough to broaden and expand the work to include exhaustive research

and investigations as to the resources of the seas, to increase the number of marine biological laboratories with competent scientific staffs, and fish-cultural stations for the propagation and distribution of commercial food fish. The development of practical ideas and methods in the economic exploitation of the fisheries; the demarcation of fishing grounds, employment of scout vessels, hydroplanes and wireless communication in locating and following up seasonal migratory fish; practical instruction in the handling and packing of fish for shipment to distributing centres; the dissemination of information as to costs together with sources of supply of gear and equipment, particularly nets, twine, bait, ice, packages and all commodities essential to production; and recommendation for the repeal of all unnecessary legislation and the substitution of genuine conservation measures are all helpful suggestions.

POLLUTION.

Pollution is exercising a great influence over our supplies of fish, particularly the anadromous salt water fishes which spawn in our rivers and brackish coastal waters, and, what is more important, the destruction by pollution of their food supply in inshore waters, such as the minute pelagic forms of plant life and crustaceans.

The waters of our rivers and harbors, along the banks of which great manufactories are located, are favorite dumping-grounds for waste materials of all kinds, the most injurious to the fisheries being oil-waste and tar. Drainage of waste oils and tar from gas-houses and oil refineries, the accidental leakage and wanton discharge of fuel oil by oil-burning vessels, are responsible, to a great extent, for the depletion of our inshore fisheries. Waters such as the Kennebec River in Maine, the Connecticut and the Hudson Rivers, New York Bay, Chesapeake Bay and many others, for years famous for their production of salmon, shad or striped bass, have in the past few years become nearly barren of these valuable fish on account of this most destructive agency—pollution. That the greed of the commercial fisherman is not wholly to blame for the depletion of these waters is borne out by the fact that, from time immemorial, fishermen have been taking the fish, and the runs have been as great one year as another, until the waters became contaminated with the pollutions of civilization.

In framing measures of conservation, the subject of pollution

should be given very serious consideration. Legislation with very heavy penalties, prohibiting the discharge of polluting materials in any fish-producing waters or in any stream emptying into such waters, would undoubtedly be one of the means of reestablishing in a very few years these former valuable fisheries.

TRANSPORTATION AND DISTRIBUTION.

Much has been written concerning transportation of fish and products of the sea. Market conditions are of such a nature that the wholesale selling price is not based on the cost of production, but upon the law of supply and demand.

The fisherman cannot store up his catch in anticipation of favorable market conditions. He must ship his fish to the distributors at the earliest possible moment. Many times during periods of glut his fish do not bring transportation charges, not considering remuneration for his labor and cost of packages and ice, nor the expense of the distributor in handing the fish. The transportation company is practically secured against loss, as its charges must be paid at time of delivery.

It is of national importance to place on our markets, without loss, but at reasonable prices, wholesome and nutritious foodfish in good condition. Fish is the most perishable of all foods and should receive the closest attention and preferential treatment. Rapid and thorough distribution is a vital factor in the development of the industry. To attain this end, better transportation facilities are essential. Tariffs reduced to a reasonable rate, insulated and refrigerated cars, with more efficient train service will make it possible for fish to be carried to the most distant points in perfect condition.

The following extract from the address of former Senator Beveridge in Indianapolis on June 7, 1922, applies very forcibly to the fishing industry:

> The product of all labor must pay railway charges, and the price of every article is affected by railway rates. Cost of living, scales of wages, profit or loss of farmer, manufacturer and merchant, all depend on this vital economic element, and whatever prevents reasonable railway tariffs and sufficient railway facilities must be removed.

Retail Distribution.—The retail distribution of fish is of vital importance to the industry inasmuch as the average consumer comes in contact with the industry, solely through the retail dealer. Careless and unscrupulous dealers have created much prejudice

among consumers by selling fish of poor or inferior quality and also by representing some of the cheaper and inferior grades to be more popular and expensive varieties. The unsanitary conditions of many fish markets is another factor in discouraging a more extensive use of sea-foods. The average housewife makes her purchases of fish only one day in each week, many believing fresh fish can be obtained only on Thursday or Friday. Due to this fact, the dealer's expenses and overhead for the entire week must come out of one or two days' business.

The housewife in making her purchases of meat does not consider quality, knowing it is up to the standard set by the Government or it would not be offered for sale; but, in purchasing sea-food, usually the first question she asks is in regard to its quality. She is invariably assured that the fish is absolutely fresh.

Practically all of the abuses retarding the wholesome increase in consumption could be eliminated by the cooperation of every branch of the industry, together with the Fisheries Bureau, in educating the public by various methods of advertising, distribution of literature describing and picturing seasonable varieties of fish and sea-food, methods of ascertaining quality and recipes for preparing the fish for table.

PRESERVING.

Freezing and Cold Storage.—The subject of preserving fish is of immense importance to the industry and is one that should be given extensive consideration. Very nearly all salt-water fish are of the migratory type and must be taken while on their migrations to shoal water. During seasons when the fish are most abundant the selling price is such that in many instances the producer does not receive enough for his fish to pay the cost of production. At these seasons dealers usually purchase for storage and preserving purposes the quantities they deem adequate to supply their trade during seasons when the varieties are not produced.

Much of the fish frozen in the past has been of indifferent quality. Frozen after having covered long distances from the point of production, exposed for sale for indefinite periods in markets, it is finally placed in cold storage for future use. Fish will not be improved by freezing and will not be in better condition when defrosted than before going through the process.

Little consideration has been given to the varieties of fish

to be frozen. Many varieties are not adapted to the process. A consumer purchasing one of these varieties, or fish of inferior quality, naturally condemns all frozen fish. Fish for cold storage purposes should be given the same care and attention as that to be used in its fresh state and frozen at the earliest possible moment after removal from the water.

At one of the large fish-freezing plants in New York City, several million pounds of fish are frozen annually. These fish are graded as to size and quality and the boxes in which they are packed are marked accordingly. Fish that are of the best quality are designated as grade "A," those graded as "B" are not of as high quality as grade "A." Each fish is inspected by an expert and nothing is permitted to be frozen unless it measures up to the standard of grade "B." Many other concerns are now practicing these same careful methods in the freezing of fish and are finding the results more satisfactory to the purchaser as well as to themselves.

Brine-Freezing.—There are several methods of brine-freezing which are claimed by their inventors to be superior to the air-freezing process. It is also claimed that the original appearance and flavor of the fish are retained, the time required for treatment being from two to four hours, according to the method used and the fish dealt with. The fish retains its quality for from one to two weeks without ice or other preservatives, and can be kept in cold-storage at a temperature of about 21 degrees F. for many months.

In view of the necessity for preserving freshly caught fish on board the fishing vessels and the desirability of placing in our inland markets high quality stock, it is desirable from the commercial viewpoint, that one or several of these methods be officially tested by the Bureau of Fisheries or the Department of Health, and if found practicable and not detrimental to the public health, advocated for general use in the fisheries.

Curing, Smoking and Canning.—While, on the whole, fresh fish will always be preferred and with improved preservation and distribution, should be obtainable everywhere throughout the entire year, there is scope for the development of curing and smoking processes, as cured, smoked and canned fish furnish a needed variety and are in much demand.

One criticism that may be made in regard to our processes

of curing and preserving is that they show very little variety, and are conducted by the same methods as were practiced many years ago. A majority of the varieties cured in large quantities consists of the so-called ground fish, herring and mackerel, while practically all varieties lend themselves admirably to various methods of curing. Curers and smokers cater principally to the popular taste, to the practical exclusion of creating demands for some of the other, and in many instances, cheaper varieties. The varieties smoked consist chiefly, in our eastern markets, of haddock and herring. There is no doubt that if many of the other varieties were smoked they would soon become as popular as the finnan haddie and the bloater or kippered herring.

It is rare for a new variety of canned fish to appear on our markets. Considering the vast quantities of numerous varieties produced during the seasons of abundance, when the value of these fish is at its lowest and the supply is far greater than the current demand, canning of every variety suitable for this purpose should be one of the means of relieving the condition of over-supply. The farmer when he reaps his harvest has an outlet for his produce in the canning factory as well as in the markets. There are very few varieties of fruit or vegetables, grown in the entire country that are not preserved in cans to become the staple supply until the next harvest.

Canning is the most economical means of preserving fish for future consumption. After the fish is canned it does not demand the same care as that required by frozen or cured fish, the ordinary storage warehouse affording ample protection for the pack.

UTILIZATION OF BY-PRODUCTS.

The waste in connection with the fisheries industry is almost beyond comprehension. The actual average of fish-flesh consumed as food is about 33 per cent of the fish as it comes from the water, the head, tail, scales, skin, bones and viscera, comprising the other 67 per cent, being waste material. The value of fish waste and of varieties unfit for food, as a by-product of a great fishing industry, is hardly realized and the nitrogenous fertilizer, oil, glue, fish-meal, etc., derivable from these are mostly lost.

To encourage the destruction of the dog-fish that roam the sea like packs of wolves and do untold harm to fish and gear, and also to utilize their carcasses and other fish waste, the Canadian Govern-

ment at one time established reduction plants in Nova Scotia. At Liverpool, England, a plant has been earning $400 a ton for the fats and $100 a ton for the poultry meal made from fish residues. To us the value of dessicated fish powder as a food for pigs and cattle, if not for men, as in Japan, is hardly known. Fish scrap contains practically all the elements of an ideal fertilizer for nearly every agricultural purpose; fish meal furnishes an excellent food for cattle and poultry. A very fine grade of leather is made from the skins of some of the larger species, principally the shark and porpoise. The scales of certain varieties, notably the shad, are valuable in the manufacture of artificial pearls. The best kind of glue is a product of fish skins.

With the increased demand for dressed and fillet fish, much residue accumulates in plants where these operations are conducted, but very little of this residue is utilized and is only a source of expense to the operators for its removal. In the meat industry the by-products are far more valuable than the dressed meat that is sold to the consumer. Every particle of the animal is utilized for some commercial purpose. The great volume of waste material and non-food fish that are now destroyed could be collected and utilized in the manufacture of various articles of commerce which would greatly enhance the value of the fisheries.

EDUCATION.

Technical knowledge is a very important asset in the fishing industry. Some of our institutions of higher learning, notably the University of Washington and the Massachusetts Institute of Technology, have included fisheries and fish-cultural courses in their curriculums. Fishery engineering will do much to place the industry on a higher plane than is possible by any other means. Every commercial fish producing state should have at least one technical institution where persons engaged in or intending to enter into some phase of the industry, can take courses pertaining to the fisheries; and for those who, for various reasons, cannot take the time to attend resident colleges and who wish to increase their knowledge, there should be extension courses provided.

Nearly every one from the producer to the consumer is in need of education to a greater or less extent. The producers could be benefitted by instruction in various economical methods of taking fish, packing and shipping other than now in common use. Many

of the methods employed by large numbers of producers are antiquated, inefficient and expensive. More efficient methods of distribution, sanitation, proper display of goods and installation of economic accounting systems by the wholesalers and retailers can only be accomplished by education.

Education of the consumer is by far more important than educating the producer or the distributor. The housewife knows the various cuts of meat and practically all varieties of vegetables, and can usually tell their quality at a glance. With fish, she is absolutely at sea. With very few exceptions she does not know one variety from another or what varieties are best suited for particular purposes. Methods to distinguish the quality of the fish are foreign to her. She may know one or two ways of preparing the fish for the table. When she purchases fish other than of the limited varieties with which she is familiar, she is experimenting with a deep mystery. Education of the public will of necessity educate the producer and the distributor. The public press, magazines, moving pictures, public school lectures and the radio are some of the means by which the public could be educated to eat more and better fish.

OYSTERS—THE WORLD'S MOST VALUABLE SEAFOOD.

By H. W. Vickers
Chairman, Conservation Commission, Baltimore, Md.

Oysters are the most popular and the most extensively eaten of all shellfish; economically, they are the most important of all cultivated water products and, with the single exception of the sea herring, the most valuable of all aquatic animals. The oyster crop of the world in the year 1913, according to Government statistics, amounted to over 42,000,000 bushels and was valued at nearly $25,000,000. Of this output, the share of the United States was 88 per cent of the quantity and 69 per cent of the value. Of the remaining portion, fully 50 per cent belong to France.

It is my intention, in this paper, to deal with the oyster problems of the Atlantic and Gulf coasts, and especially of the Chesapeake Bay, the world's greatest oyster ground. Any food product of so great commercial value as the oyster and one which has given a livelihood to thousands of citizens for generations, warrants the most serious consideration of those entrusted with the care and preservation of the nation's fisheries.

The natural oyster bars and rocks of the North Atlantic States became practically exhausted many years ago. The oyster culturists of those states had no opposition when they determined to raise oysters by scientific methods. The main thing they lacked was the oysters to furnish the spawn and the seed oysters for the start in the industry. Naturally their attention was focussed on the section of the greatest natural production—Chesapeake Bay. Then followed the greatest transplanting of oysters ever known in the history of this country. From 1875 to 1900 it was a common sight to see a dozen two or three-masted schooners from New England anchored in the waters of Tangier Sound, loading seed oysters, marketable oysters, and shells which had been scraped from the rocks of the Sound, to be freighted to the northern planting grounds. The Maryland oystermen were pleased with the idea of a market, especially in the early spring, and no thought was given to the fact that they were selling their future livelihood. Tangier Sound alone was at that time producing about 4,000,000 bushels

of oysters a year and it required many years for the fishermen to awaken to the fact that the oyster rocks were exhaustible. It was but a few years after the migration of the Chesapeake oyster, however, before the New England oyster culturists started on their successful career as oyster growers. The cultivated oysters commanded a higher price and the product was marketed in a manner which greatly increased its value. The little State of Rhode Island developed bottoms which brought in considerable revenue, the oyster planter paying a rental of $10 an acre a year. The State of Connecticut sold its bottoms in fee, a great mistake from the state's standpoint as it was later realized, since it materially reduced the annual revenue from oyster bottoms.

It is said that until 1910 Massachusetts, Rhode Island, Connecticut, and New York were most successful with the cultivation of the oyster. The culturist had met and overcome all difficulties. The most dangerous and serious enemy to the northern bivalve, the starfish, had been successfully controlled by means of "tangles," and even the drill, with its rasping tongue, did not affect successful oyster propagation in New England waters.

For practically the past ten years, however, the necessary set of spat has failed in northern waters and thousands of acres of the best planting bottoms are now considered of little value. The cause of this serious setback has been investigated by the Bureau of Fisheries for several years, and while their report on this subject has never come to my attention, I understand that pollution of the waters is largely responsible for the lack of young oyster larvæ, and the most serious pollution has been found to be caused by oil sludge from oil-burning ships.

The South Atlantic States and especially Louisiana, which borders on the Gulf, have made much progress in oyster propagation and have experienced a noteworthy augmentation of yield during recent years. A government report in 1913 gave the seven leading oyster states at that time as Rhode Island, Connecticut, New York, New Jersey, Maryland, Virginia and Louisiana; in each of these states over 1,000,000 bushels of oysters were marketed annually. Virginia was the ranking state as regards production, with over 6,000,000 bushels, followed by Maryland, with over 5,500,000 bushels, and Connecticut with 4,000,000 bushels. As regards value of oysters taken, Connecticut and New York led, with

over $2,500,000 each, followed by Virginia and Maryland with about $2,250,000 each.

One of the highest authorities in this country once said that nowhere in this country is there any excuse for continuing to rely on public oyster grounds as sources of supply, and the proposition to discourage or prohibit individual control of land for agricultural purposes would not be less absurd than to prevent or retard the acquisition of submerged lands for aquicultural purposes. It would seem that this is a most reasonable and progressive statement, yet representing a part of the Chesapeake Bay region where we have always had to depend on our large natural oyster rock areas for production, I feel that we must still rely on our public grounds and adopt strong conservation methods to prevent their depletion. The 1913 statistics of the oyster industry show the preponderant importance of Chesapeake Bay; an output of over 11,000,000 bushels, valued at more than $4,250,000, and the production of the Bay since has not varied more than 2,000,000 bushels from these figures.

In reviewing the statistics of the production of the oyster-producing bottoms of Maryland between the years 1865 and 1920, it may be of interest to know that these bottoms produced 453,000,000 bushels of oysters which had a money value of over $200,000,000, or an average of $3,571,428 a year. The greatest production in Maryland was between 1873 and 1893. The survey of the oyster bars of Maryland, 1906-1912, showed that the natural oyster rocks beneath the waters of the State covered over 200,000 acres at that time, although many thousands of acres had become depleted since 1885 and this depletion was on the increase.

MAINTENANCE OF NATURAL OYSTER AREAS.

Believing that it is essential to maintain the natural oyster bars and rocks in the waters of the State of Maryland, we are returning cultch, in the shape of oyster shells, to the partly depleted bottoms, and are leasing barren areas with suitable current and density conditions for oyster culture. During the long period from 1865 to 1920, aside from the cull law on the natural oyster rocks, nothing whatsoever was done to maintain the oyster bars. The fishermen of Maryland continued to resort year after year to the bars for a livelihood, and this overfishing naturally caused depletion. During the past two seasons, over 250,000 bushels of

shells have been carefully scattered on selected depleted bottoms with excellent results. The writer is informed that the State of North Carolina has also adopted this method. It is not believed, however, that this method will restore the natural bars to their original condition, but it is believed that shell planting will stem depletion and conserve this great natural wealth lying beneath the waters of the Chesapeake.

OYSTER ENEMIES.

While the oyster has many enemies in almost every stage in its career, these vary in size and kind in certain regions of the Atlantic and Gulf coasts. The oyster growers of Long Island Sound and adjacent water suffer large losses from the inroads of starfishes, which come in from deep water and move in waves over the bottom, devouring every oyster in their path and sometimes destroying several hundred thousand bushels of marketable oysters in one state in a single season. It is remarkable that a weak creature like the common starfish should be able to prey on an animal so strongly fortified as an oyster. In the Chesapeake region the powerful jaws of the black drumfish may literally clean out an oyster-bed in one night, while the Gulf States have to deal with the drill and the Pacific Coast States with a species of stingray. The most serious recent enemy of the upper Chesapeake Bay oysters is the mussel, which practically covered the oysters on the Bay and river bars during the past season and materially affected marketing the bivalves. The Bureau of Fisheries attributed this unusual growth to the high density caused by light precipitation in the winter and spring of 1920 and 1921. The heavy rainfall during the spring and past summer has caused the mussels to fall from the oyster shells and the condition is much improved.

OIL POLLUTION.

Our fin and shellfisheries as well as our wild fowl are now subject to one common enemy—oil pollution—and unless concerted action is taken in the near future by the several interests concerned, this great natural wealth seems doomed to destruction. The solution of this problem has been before the Congressional Committee on Rivers and Harbors for many months, and it is hoped that the American Fisheries Society will see fit to ask Congress to expedite action to relieve the situation.

Discussion.

MR. WILLIAM C. ADAMS, Boston, Mass.: I should like to ask Mr. Vickers a question, with respect to this oil pollution. Oil coming in on the surface of the water and precipitated on the clam flats and adjoining areas by reason of the rise and fall of the tide can very easily pollute those areas; if it remains on the surface of the water it is, of course, very deadly in its effect upon wild fowl. But the point I would like to be informed upon is the extent to which this oil or waste will precipitate and lodge on oyster beds, perhaps a number of feet below the surface of the water. To what extent has your investigation shown that that is the fact?

MR. VICKERS: This oil pollution destroys the oyster spat, which starts on the surface of the water and goes down gradually. It has the same opportunity to destroy any other animal life in the water. It has been noticed down on the beds, on the oyster ground.

MR. JOHN N. COBB, College of Fisheries, Seattle: The oysters were practically all destroyed in San Francisco Bay as a result of the dumping of sludge from the oil tankers. The vessels bring the oil in and take it up to the head of the bay, where they discharge it at the great refineries, and then come down the bay—or used to, at least—and dump the sludge. The sludge works around the beds at low tide, killing the spats that are floating, and affecting the oysters on the bottom. We have had the same trouble in Puget Sound. There we have a tide varying from fifteen feet up to twenty feet, which quite freely exposes many of the beds. Some of them are protected by the artificial dykes, but any oil deposited in the neighborhood of those that are not so protected usually spreads around, gathers on the shells and kills the oysters.

COMMERCIAL FISHERIES.

By Charles E. Wheeler
Stratford, Conn.

The question has been raised as to what is wrong with our commercial fisheries. In this connection it can be said that in some localities the trouble is that fish are getting fewer and prices consequently higher, while in other localities the fishermen have been forced to liberate tons of fish because they could not get enough for them to pay for barrels and ice. So the answer to the question in some sections is small production, and in others small returns.

In the course of over thirty years of experience in the fishing and shellfishing industries of New England, the writer has noted many changes that have affected these industries commercially. Many varieties of both fish and shellfish that were once abundant are now on the verge of extermination in some localities, and sadly depleted in others. Many streams that were once pure and productive are now grossly polluted and barren.

Many little fishing settlements along the shore, once bright, thrifty spots, now show signs of deterioration. The net-reels are tumbling down, the fishing boats are laid up to die, the nets are being utilized as poultry fencing and the fisherfolk are busy in other walks of life simply because "Fishin' aint what it used to be." And in answer to the question: "Why isn't it?" one hears either, "Not fish enough to pay," or "Not enough for our fish to pay." Commercial fisheries, like other industries, are dependent upon production first and upon distribution and returns next.

Inasmuch as many fishermen in New England have quit fishing because there are not enough fish locally to make fishing profitable, it is obvious that the trouble here is on the production end. It is equally obvious that in the south where trap fishermen have been forced to liberate thousands of barrels of fish because they could not get enough for them to pay for handling and shipping, the trouble is on the sales and distribution end.

In considering fish production from the viewpoint of Nature's supply, one finds that fish do certain things, under certain

conditions, at certain times of the year and that their actions are governed wholly by a natural instinct. In the beginning, God created fish and a habitat and food supply for them. Since that time Nature has been taking care of this work very efficiently until foreign influences introduced by man have handicapped the work. Some of the provisions of nature were that matured fish should deliver their spawn under favorable conditions and in suitable areas; that the spawn should hatch, that food properties should be present in the water to take care of the little fry during its babyhood, that enough of these fry should escape their natural enemies and mature so as to return and deliver their spawn.

This process went on for ages successfully and would be going on more effectively today were it not for the unnatural conditions imposed by man. With the introduction by man of ingenious types of gear and nets for catching fish, and the destruction of spawning beds and food properties in the streams by pollution, the candle has been burning at both ends for the past fifty years without much thought being given to replacing the candle. We are now at the point where we realize that unless something real is done in the way of rebuilding our fisheries, this extremely valuable natural resource, over which we are but custodians, will be depleted beyond restoration and the coming generations will have been legally, morally and economically wronged by our wilful wastefulness.

The common-sense version of the situation is that first we need to conserve a plentiful supply of matured stock for healthy spawners; next we must provide suitable places, as nature did, for these specimens to spawn in; we must make it possible for them to reach these areas and protect them while they are there; we must protect the quality and quantity of our stream flow so as to provide sufficient food for the young fry; we must protect these fry from UNNATURAL enemies so that a sufficient number will mature and restock these same areas another year. This applies to the natural propagation of shellfish equally as well as to the production of the finny fish species.

"Getting down to brass tacks," this means that the life of our commercial fisheries depends on the elimination of such pollution as is deleterious to fish or fish-food life. It means that our stream flow must be augmented by reforestation of drainage

areas. It means that restrictive catching laws must be enacted so as to make certain that enough spawners reach the spawning beds. It means that spawning areas should be designated in the rivers, and in as near the same localities as is practicable, that nature originally provided for spawning purposes.

The question has been asked: "How long would it take to restore our fisheries if stream pollution was eliminated?" The answer to this is that the work of restoration would commence immediately as is evidenced by better conditions in Connecticut since the quality of the water here has been greatly improved by reason of the industrial depression. Since the war our factories have operated but feebly, with the result that little or no manufacturing wastes found their way into many of our streams. The fish sensed the better quality of water and immediately ascended the sreams to points many miles above where they had been for ten years. This is positive proof that just as soon as man improves the conditions in the streams, just so soon will nature take advantage and commence to do her part in the restocking of barren areas.

The volume of possible returns may be estimated by the results obtained in California waters where shad and striped bass were introduced many years ago. Neither of these fish were natives of the west coast, but were shipped there from eastern points, with the result that in a few years California was able to ship shad and shad roe to eastern points in carload lots, and striped bass are now very plentiful in California waters. Surely if these results are possible in waters foreign to these species, then success must follow sensible efforts to reestablish them in the rivers that nature chose for them originally.

Much has been said about the advisability of a Federal migratory fish law. It would seem that inasmuch as a similar law had worked wonders in rebuilding our depleted flocks of wild fowl, it might be well worth trying in the interest of our fisheries. It would at least bring the Government face to face with a rotten condition of stream pollution which together with severe overfishing is fast exterminating several species and sorely depleting a very valuable natural food resource.

It would not be fair to the commercial fishermen, the fellows who actually catch the fish, to pass on without saying a word or two about the modern method of marketing. When there is a

run of fish the fishermen are busy catching fish and tending gear; they have no time for marketing advantageously; they ship everything to commission houses and take chances as to whether they get something or nothing for their product. The result of this method is that invariably the fisherman gets little or nothing for his large consignments and but a fair price for his small catches. In actual figures it can be shown that on May 16, 1921, the return for 45 barrels of weakfish was $69.27, or a little less than four-fifths of a cent a pound; that on the same day weakfish were wholesaling in New York at 18 cents a pound and retailing in Connecticut towns for 25 cents and 28 cents; that on July 29, 16 barrels of weakfish brought a net return of "sold for expenses," and that on that same day weakfish were bringing 18 cents and 20 cents wholesale in New York; that on August 1, 30 barrels of butterfish and weakfish brought $97.26 in New York, and that on the same day in New York 30 barrels of these fish brought over $1,000 and were retailing in Connecticut for 25 cents and 28 cents per pound.

Many similar instances might be cited, but what's the use? If the commercial fishermen will continue to ship their fish to the commercial fish monger and gamble on the returns they are to get, they cannot blame anybody but themselves if they get "stung."

It might be well for them to study the advisability of forming an exchange big enough to operate their own cold storage plants, and market their product through the exchange. It is a good gamble that they would get more for their fish and that the consumer would get better prices which would tend to create a better demand.

Summing up it can be said that the real panacea needed to resuscitate our commercial fisheries is the elimination of pollution from our streams, the designation and protection of spawning areas, and conservative fishing laws. The matter of better marketing methods will be solved by the fishermen eventually, as it was by the fruit growers and others.

THE PROBLEM OF MARINE FISH CULTURE.

By C. M. Breder, Jr.
New York Aquarium, New York, N. Y.

Constructive efforts put forth in any direction by an individual or a group are almost certain to be attacked in a more or less violent manner by others, apparently as a matter of ancient custom or because of some dislocated sense as to the appropriateness of criticism on the part of the self-appointed critics. This promiscuous picking to pieces of our contemporaries' labor, while sometimes simply obstructive to the work it is intended to aid, nevertheless, has its place either when it is backed by the knowledge of a student of the particular field concerned, or when brought up by one sufficiently removed from the scene of activity to gain a fair perspective of the whole. The most pleasing results possible from such criticism are usually discussions and controversies arising therefrom. These, if carried on in the proper spirit, become the stimulus necessary to arouse an interest sufficient to goad active minds to the point of developing improvements great enough to raise the results of the work from mediocrity or failure to a measurable degree of success.

The actual value of the cultivation of marine food fishes has long been open to question, and in consequence has become the target for both just and unjust criticism. That this condition has existed for such a long period of time is largely due to the great difficulty to be encountered in any attempt to measure the effectiveness of fish cultural work on marine fishes. Among the prime reasons for this difficulty is the fact that many of the little understood factors contributing to the production of oceanic conditions, cause annual fluctuations of considerable size in the abundance of fish life which tend to invalidate any deductions based on the statistics of catches made by commercial fishermen, not to mention such other factors as have been introduced by man himself. Partly, at least, for these reasons marine fish culture has found it necessary to use as a basic assumption the general proposition that the figures in reports showing that immense numbers of fry have been planted, actually represent some tangible result, which of necessity must follow the liberation of

great quantities of fish larvæ. However the truth of this proposition is by no means a proven fact. With these considerations in mind the present paper has been penned and its single reason for existence is the hope that a perusal of it will aid in the stimulation of constructive thought in the minds of fish culturists interested in the development of the marine hatchery.

It is well to note here that the case of the older art of cultivating lacustrine and fluvatile spawners is another matter, and any criticism of its practice must, in almost all cases, be directed against the efficiency or practicability of the technical methods involved. If for example we select a given pond, known to contain not a single individual specimen of certain desirable species, and cause it to be stocked with the desired fish in such a manner that the species is able to establish itself without injurious disturbance to the previous balance of life in the pond and in sufficient numbers to be worth the cost and trouble involved, the effort may be counted a success. Simple observation is sufficient to prove such a case, as all that can be criticised is, for example, that a particular method of handling or incubating is open to improvement in one way or another. In the case of marine fish culture, on the other hand, the underlying proposition may be attacked; for in the study of oceanic conditions such direct observation as is applicable to small bodies of fresh water is impossible, owing chiefly to the vastness of the scale of the open sea. Therefore, to say after a few years spent in cultivating a particular marine species, that a slight increase in the amounts brought to a particular fish wharf furnishes evidence of the effort's success, is simply to ignore the vast and uncontrollable forces that operate to make abundant or scanty the fishing of the year. Each such factor is in itself of a magnitude sufficient to dwarf by comparison the best known efforts of man in the cultivation of these fishes. Until nearly all of these factors are much more thoroughly understood, the comparison of the fisher folks' fluctuating fortunes from year to year must continue to mean but comparatively little. Therefore, as previously explained, the question here to be considered is not one of technical methods, even as obviously bungling and crude as are some of the current practices, but rather refers to the possibility of handling intelligently and efficiently a problem of such dimensions with our present knowledge of oceanic conditions, or rather, lack of it.

For this reason it would seem that the money spent in maintaining such supposedly useful stations might better be expended on thoroughgoing investigations with the view to determining as accurately as possible just what value such fish cultural operations may have. Ultimately the question to be considered enters the field of political economy. Can the taxpayers' money now being directed to the support of marine hatcheries be shown to be doing what is expected of it?

Europeans have paid more attention to this study of the rationale of the problem than have our own students and a number of the former have already committed themselves to the belief that the entire efforts of cultivating marine fishes should be thrown into the discard, because, according to their views, the only real factors controlling the fluctuations of oceanic fishes are to be found among various climatic functions far beyond the present control of man, and it was not without much study and careful reasoning that they have arrived at their conclusions. These naturalists have taken into consideration such factors as the melting of polar ice and the seasonal variations in the amounts of sunshine and shade. For the present, however, we may leave this phase of the problem without discussing the probability of truth to be found in their beliefs and content ourselves with the platitude that the ocean or even an arm of it cannot be treated simply as an overgrown millpond but must be considered in proportion to its increased complexity as well as its greater size, for it must be borne in mind that any important bay or sound always has a considerable contact with the open water.

A consideration of the reports of the United States Bureau of Fisheries will in itself demonstrate the truth of some of these considerations. For example, a study of the statements of the amounts of cod, *Gadus callarias* Linn., landed at Boston, Gloucester and Portland, together with the number of cod fry recorded as having been liberated from the Woods Hole hatchery will reveal a rather interesting condition. If there are equal numbers of both sexes of this fish in the sea, the following corollary must be true. Out of the million odd eggs laid by each female and fecundated by the milt available from one male, but two would have to hatch and reach the age and spawning condition of the parents which may here be called "maturity," to maintain a *status quo*.

If three survived the new generation would be 50 per cent greater in number than that of the parents, and so on. Codfish are no doubt perfectly promiscuous in habit, and as the sexes seem to vary greatly in relative frequency from time to time we will assume there are two males to every female. While this is giving an overabundance of males this liberal allowance may be used here as a basis without doing great violence to the point to be made. Accordingly, then, in a spawning school each female would have available the milt of two males to fertilize her ova, and therefore an average of three eggs from every female would have to be successful to maintain the said *status quo*. In order to draw a sharp mental picture of what this means recourse may be made to one of the much overworked methods used by statisticians to bring home the point. As cod eggs average one-eighteenth of an inch in diameter a medium sized "market cod" could lay a string of eggs which if placed in a single straight line would be over one and one-quarter miles in length.[1] Of this mileage only one-sixth of an inch would have to reach "maturity" to keep the number of cod in the sea at a constant figure. An inspection of a certain report[2] shows that 77,659,000 fry were liberated from the Woods Hole hatchery during the winter of 1917-18. Assuming for the sake of the discussion that the naturally spawned eggs lost twice as many of their numbers between the time of ovaposition and the day their artificially incubated relatives were liberated, than did the latter, due to non-fertilization and the vicissitudes of early life in open water, and also that after this time the cultured fry now being subjected to like conditions, equalled the naturally spawned fish in losses, then a net initial advantage of 100 per cent would be possessed by the fry hatched in cod boxes. As cod are certainly not increasing perceptibly in numbers, according to simple proportion it may be said that the total effective output of the station for the year would, by these figures, be about 311 fish, available of course to the fishermen some years later. This figure is far

[1] Cod 6½ pounds in weight deposit on an average 1,500,000 eggs which number if arrayed as described would reach for that distance. By "market cod" fishermen mean all under 10 and over 2½ pounds in weight, which excludes the very small or scrods and the very large, the latter of which form the bulk of their catches.

[2] Report of the U. S. Commissioner of Fisheries for the fiscal year 1918 with appendices—Hugh M. Smith, Commissioner. Appendix I—The distribution of fish and fish eggs during the fiscal year 1918, Document 863, p. 75.

too liberal as it was arrived at on the assumption that 1,500,000 eggs is the average number per female, whereas this figure is much too low. Furthermore, it is hardly probable that stripped spawn has a 100 per cent advantage over the natural product, since it is known that fish culturists expect to obtain only from 25 to 50 per cent good eggs, due to the fact that the eggs do not all ripen at one time.

No consideration has been given above to losses incident to handling and planting, which while highly variable are no doubt considerable for any one entire season. All the eggs hatched at Woods Hole moreover are not taken in the above manner, the Norwegian method also being used in which live cod are allowed to spawn more or less naturally in large tanks. The only advantage that can be claimed for this method is that the eggs are afforded protection during incubation, for it is the practice to release them immediately on hatching. Records show that 90 to 95 per cent of the eggs are fertilized by this method and therefore it can hardly be assumed that much better results are to be obtained from a few fish in confinement than from a hoard in the ocean. It is further hard to believe that the planted fry are as well able to withstand the vicissitudes due to oceanic environment as are those which have been in open water from the start. The simple shock of change must work some havoc among them. The previously given figures are ridiculously liberal to the hatcheries and besides none of these draw-backs have been reckoned with. What would be the actual number of mature hatchery fish at the end of four years if these could be figured in, to say nothing of numerous others which have not even been mentioned? Certainly it could be at best only a small fraction of 311.

For the year of 1921, four years later, the Bureau of Fisheries' statement of the quantities of cod landed at Boston, Gloucester and Portland[1] is as follows: Large (10 lbs. or over) 33,238,407 pounds; market (over 2½ and under 10 lbs.) 19,126,030; and scrod (1 to 2½ lbs.) 1,150,577 pounds. Exact figures are not available but it is believed that the average weight of the large cod is about 20 to 35 pounds, depending on the grounds from which taken and the time of year. The large and market cod taken together probably average about 15 pounds, while that of

[1] Statistical Bulletin No. 517—U. S. Bureau of Fisheries.

the scrods is probably near 1¾ pounds. From this we may broadly say that about 3,490,962 adult cod and 657,472 scrod were landed in 1921. By simple calculations according to this reasoning one large cod in every lot of 13,375 would be a hatchery fish as would one scrod in every lot of 13,148. These smaller fish would naturally be expected to be of a later year's work, but as approximately a like number would be taken from the group which form this year the large and market fish a season before, the figures may stand as being reasonably correct. This would give a grand total of 4,003 pounds of cod, or less than .008 of one per cent of the total catch for the year as hatchery fish. On the face of it, it is obvious that these calculations are absurdly liberal to the hatchery fish, for it is assumed that the fishermen hailing from these three major ports would be the only ones to catch these fish and that they would catch all of them, that is take 16 per cent as scrod one year and the remainder the following. A long list of further reasons why this is a high figure might be given but it would be superfluous for our purpose here.

Any one, with the figures available, might calculate the cost per pound of a year's output of hatchery cod which is certainly composed of considerably less than 311 individuals made available to the fishermen by this method, and compare it with the actual value of this amount of fish. Neglecting the Norwegian method which takes fish which would not have necessarily been caught otherwise, and granting that all of the fish stripped would have died anyway, can it be said that this amount of codfish is worth the money, time, and energy expended? It is pointed out finally that this number, 311, is perfectly absurd because at every step the calculations have purposely been placed way out of the reach of even extraordinary success just to show that even then no important effect could be expected. A very minute fraction of this .008 of one per cent is all that could actually be obtained in practice.[1]

[1] Data and assumptions on which calculations were based: Cod reach maturity usually in about the fourth year. They are then generally about two feet long and weigh over six pounds. A 25-pound fish may lay 2,700,000 eggs and a 75-pound one 9,100,000. A 6½-pound fish lays on the average of about 1,500,000 eggs. It was assumed that this is the average of all spawners. The number of fry 77,659,000 liberated at Woods Hole in 1917 was doubled (155,318,000) because of the assumption that they had twice the advantage of the wild fry.

Three fish per female are supposed to attain "maturity": Then 3 : 1,500,-

The cultivation of flatfish, *Pseudopleuronectes americanus* (Walb.) could be questioned in a similar manner with the additional criticism that all the fish are taken from the spawning grounds and would not have necessarily been captured otherwise. At present the practice is simply to let these fish which are captured expressly for the purpose, spawn in large wooden tanks and to liberate the fry at hatching, the only advantage possible being that of protection of the incubating eggs. From whatever value this may have must be deducted the losses incident to handling both the ripe fish and the fry, as well as the fact that the fry are generally deposited in a small area where they are more liable to attack from their natural enemies, until they can scatter, than would be the naturally spawned ones which at no time would be expected to be so congregated in a small area. Further explanation would be too nearly a repetition of the cod story so it may be omitted in its entirety. In fact, similar views might be expressed concerning nearly if not all marine species at present cultivated.

The quantities of practically all marine food fishes fluctuate annually in most surprising numbers, as before noted, from causes obviously not due to the activity of man, so that it becomes next to impossible to arrive at any definite conception as to the value of such fish culture from a study of fishery statistics even over long periods of time. Besides, other factors, introduced by man himself further complicate and lower the value of any conclusions so arrived at, such as the continual improvements both in gear and methods, to say nothing of the difficulty or impossibility of comparing statistics compiled in various ways.

Nevertheless is there not some angle from which the aggravating problem of marine fish culture may be more successfully attacked? The comparatively recent theories of certain

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000::x:155,318,000. x=311 fish.

Cod landed in 1921:

Large and market cod	52,364,437	pounds.
Scrod	1,150,577	pounds.
Total	53,515,014	pounds.

Large and market cod together average 15 pounds apiece. Scrod average $1\frac{3}{4}$ pounds apiece.

Then there were landed 3,490,962 cod and 657,472 scrod. By proportion of the 311 hatchery fish, 84 per cent were adults and 16 per cent (from the next year) were scrod, or 261 and 50 fish respectively, that is: $261 \times 15 + 50 \times 1\frac{3}{4} =$ approximately 4,003 pounds of cod as hatchery fish or under .008 of one per cent.

Europeans concerning the causes of fluctuations of fishes from season to season give promise of developing into an interesting and valuable viewpoint bearing on the future of the husbandry of such fishes. It has been known for some time that practically all marine fry of commercial interest reach a very precarious stage of existence in from a few days to two weeks or more after hatching, its time of appearance varying, of course, with each species. In captivity even under the particular conditions possible in an experimental laboratory it has been found next to impossible to carry salt water fish successfully beyond this point; nearly all species dying at the expiration of this definite length of time which is about coincident with absorption of the yolk sac. Apparently at, or some time before, this stage minute forms of plankton as food are necessary in order to wean the fry gently from its earliest mode of obtaining nourishment. At least one reason for such small fry to fail of survival in captivity is found in the difficulty of procuring this microplankton in the proper quantity and quality. As in the final analysis plankton is dependent chiefly on sunlight and temperature, the European oceanographers deduce that both these factors are largely involved in the fate of the fry for any one year. It is in this connection that polar ice and the conditions of the sky are brought in by them. As what are considered favorable seasons to this microplankton occur but periodically, it follows that larval fishes dependent on such would likewise flourish only periodically. Scale examination substantiates this largely. That is, practically any school of adults shows a great preponderance of some particular year class. Figuring back this has been found to coincide well with some year especially favorable to these food organisms. These successful years seem to be able to carry over the more numerous poor ones when nearly all of the fry are annihilated.[1] When this matter is better understood it may be turned to good advantage in the matter of the management of marine hatcheries, as it at least partially accounts for the high mortality of marine fry at a set time after hatching. If the proper kind of plankton could be cultivated and fed to the fry in such a manner as

[1] These views have been summarized and are set forth lucidly and without the use of technical terms in the recent publication, "Ocean Research and the Great Fisheries," by G. C. L. Howell, M. A. 1921. The Clarendon Press, Oxford, England.

to carry them past this period, especially in the more frequent unsuccessful years, probably marine fish culture could be placed on a more sound footing, if indeed it is possible to influence the number of fishes in the ocean by work on such a comparatively small number of individuals.

The writer, as a former employe and as an ardent admirer of the purposes and traditions of the United States Bureau of Fisheries, wishes to emphasize that the foregoing remarks are not intended to be mere destructive criticism of marine fish culture in America and wishes to reiterate the hope that they may stimulate constructive thought in the minds of fish culturists in such a direction that marine fish culture may some day, if possible, be raised from its position of questionable value to that of its companion operating in the fresh waters which has its worth absolutely established. Before salt water fish culture can compare with it much research will be necessary, and it is to be hoped that the Bureau of Fisheries will see fit to carry on such research intensively or at least initiate and supervise efforts in that direction.

[Practically all of the facts and figures used as a basis of reasoning here have either been taken from the publications of the United States Bureau of Fisheries direct or from various members of its personnel. The writer is indebted to Mr. J. T. Nichols, of the American Museum of Natural History, for a number of criticisms and suggestions, and to Mr. R. H. Corson, a private individual and angler of unusual breadth of vision, who is at present collaborating with the Bureau of Fisheries, as he must bear the responsibility of sowing the seeds which have led to the publication of these thoughts.]

PRELIMINARY REPORT ON THE TOXICITY OF COLLOIDAL SULPHUR TO FISH.[1]

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INTRODUCTION.

The present paper contains a part of the results of investigations which were primarily undertaken in connection with the study of the toxicity of lime-sulphur mixtures. It has long been known that sulphur powder is effective in controlling the mite and certain fungi. Sabbatani (1) has shown that the action of colloidal sulphur is more powerful than that of the other forms of sulphur. These facts induced the writer to conduct some experiments to learn the toxicity of colloidal sulphur to goldfish.

Hydrogen sulphide dissolved in water has been known to change to colloidal sulphur on slow oxidation. (Taylor 2.) It has been reported that hydrogen sulphide develops in considerable quantities in the Black Sea, in the Norwegian threshold fiords, and in oyster pools of the Norwegian Coast, as well as various other small sea basins. The statement is made that these oysters are frequently killed by sulphur poisoning or lack of oxygen (Murray and Hjort, 3). Hydrogen sulphide is also introduced into waters by illuminating gas works and various industrial processes, such as paper manufacture (Shelford, 4.) In all these cases there would be a zone of water in which hydrogen sulphide occurs in the presence of oxygen, so that there would probably occur a zone of water containing colloidal sulphur. As will be seen later, the writer's experiments have shown that colloidal sulphur is quite strikingly toxic to goldfish. Hydrogen sulphide is also known to be toxic, but no comparisons have been made. Such comparisons would be made with difficulty but it should be possible to determine the relative toxicity of mixtures of the two and colloidal sulphur alone.

Attention must, therefore, be called to the fact that hydrogen sulphide is dangerous in the presence of oxygen, both on its own

[1] Contribution from the Zoological Laboratory of the University of Illinois, No. 221.

account and on account of the production of colloidal sulphur. In view of these facts the results obtained in the toxicity study of colloidal sulphur are of some interest to those who are concerned with culture of fish, oysters, etc. The results are, therefore, presented as a preliminary paper.

METHODS AND MATERIALS.

The experiments were conducted in a constant temperature tank. The water contained in the tank was kept at a temperature of about 20° C., which did not vary more than 0.5° C.

The goldfish used for experiments was *Carassius carassius* L. The criterion by which the writer determined the time of death was cessation of all the movements. A dying fish was carefully watched, and when all the movements (of the eyes, fins, mouth, etc.), ceased, it was touched rather vigorously with a glass rod and watched for two or three minutes more. When this was done, the fish responded with the movements of the mouth, fins, etc., if it was still alive. When there was no response the fish was considered dead.

Samples of Colloidal Sulphur.—A few methods were tried and discarded. The method of Raffo (5) was adopted with slight modifications. The procedure was essentially the same as described by Raffo, so that it is considered unnecessary to describe it fully in this paper. A few statements, however, are necessary. When the amorphous soluble sulphur was obtained by precipitating with sodium carbonate, the clear supernatant water was decanted, and an amount of distilled water sufficient to dissolve all the precipitated sulphur was added. The solution was then poured into collodion dialysers and dialysed for at least three days. In most cases the solution was dialysed first with ordinary distilled water for three to five days, and then, with conductivity water for one to five days. During the course of dialysis much of the sulphur dissolved in the solution was precipitated and the concentration was gradually decreased. It was, therefore, necessary to dialyse for shorter periods to get stronger solutions.

For this reason the duration of dialysis was not always the same. Because of the instability of the colloidal sulphur solution the writer could not prepare samples of colloidal solution very uniformly. Some of the samples were milky, some were slightly opalescent, while others were perfectly clear and yellowish, showing that they were very good colloidal solutions. A good colloidal

solution of sulphur did not show any sign of change during the experiment.

Results of experiments are shown in the following table:

RESULTS OF EXPERIMENTS IN STUDY OF TOXICITY OF COLLOIDAL SULPHUR.

Sample.	Concentration of sulphur.	Weight of fish.	Survival time.	Date of Experiment.
	Per cent.	*Grams.*	*Minutes.*	*1922*
VI, d	0.210	2.7	58	March 30
	.210	3.7	55	Do.
	.210	2.7	71	Do.
	.210	2.7	48	Do.
V, c	.201	4.0	99	March 20
	.201	3.0	74	Do.
VI, b	.207	3.0	50	March 28
	.207	3.0	45	Do.
III	.20	4.0	72	Feb. 22
	.20	2.3	78	Do.
	.133	3.1	68	Feb. 22
	.133	2.0	77	Do.
VI, a	.101	3.6	78	March 27
	.101	2.9	83	Do.
	.101	4.2	70	Do.
	.101	2.1	65	Do.
VI, e	.084	4.0	71	March 31
	.084	1.6	110	Do.
III	.080	4.0	97	Feb. 22
	.080	2.3	82	Do.
II	.073	1.75	120	Feb. 16
	.073	3.0	90	Do.
VI, c	.074	2.7	108	March 28
	.074	3.1	103	Do.
	.074	2.6	77	Do.
	.074	3.7	87	Do.
IV, a	.061	4.0	80	Feb. 27
IV, d	.050	2.6	133	March 1
	.050	2.5	100	Do.
IV, g	.057	3.5	130	March 7
	.057	2.6	110	Do.
VI, e	.042	2.7	126	March 31
	.042	2.7	126	Do.
IV, a	.040	3.6	150	Feb. 27
IV, c	.041	3.0	87	Feb. 28
	.041	2.3	175	Do.
IV, a	.030	4.0	100	Feb. 27
	.030	1.8	139	Do.
IV, e	.034	5.0	165	March 2
	.034	2.0	155	Do.
IV, c	.027	4.0	117	Feb. 28
	.027	2.3	140	Do.
V, a	.023	3.6	215	March 18
	.023	4.0	172	Do.
	.023	2.8	124	Do.
V, b	.020	3.0	230	March 20
	.020	3.1	210	Do.
IV, c	.016	2.8	315	Feb. 28

An experiment was carried out with Wackenroder's solution, concentration being about 0.01 per cent. Fishes kept in this solution for 24 hours did not die.

Control Experiments.—According to Raffo and Mancini, (2), (5), an impurity which is present in an appreciable amount in the colloidal solution of sulphur prepared by Raffo's method is sodium sulphate. This substance could not be completely dialysed away. A solution of colloidal sulphur prepared by Raffo contained about 4.5 per cent of sulphur and 1.5 per cent of sodium sulphate; i. e., of about 6 grams of solids contained in the solution about one-fourth was sodium sulphate. Now, the strongest cencentration that the writer used was about 0.2 per cent.

The writer considered that the amount of sodium sulphate which might be contained in the writer's solution would not affect the results of experiments. The writer, however, conducted a few experiments with sodium sulphate as control for the experiments with colloidal sulphur solution.

Experiment 1. 0.05 Per Cent Solution of Sodium Sulphate. March 24-25, 1922.—Two fishes (one 3.25 grams and the other 4.15 grams) were kept in the solution for 24 hours, yet they did not seem to have been affected at all.

DISCUSSION OF EXPERIMENTS.

From the rather meager data shown above, the survival time curve and the velocity of fatality curve were drawn. (See the graph.) It is considered that these curves show the relation between concentration and toxicity approximately. From the results of experiments and the curve, the theoretical threshold concentration was estimated to be somewhere about 0.008 per cent.

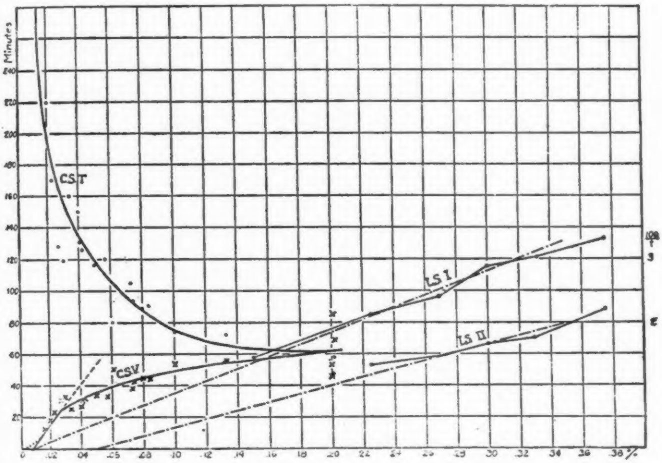
The straight line part of the velocity of fatality curve is very steep, showing that the toxicity is increased suddenly with a slight rise in concentration. Above about 0.03 per cent the rate of the increase of toxicity becomes smaller.

The theoretical threshold concentration of sulphur contained in lime-sulphur mixture is 0.009 per cent for lime-sulphur I and 0.005 per cent for lime-sulphur II, respectively.

The velocity of fatality curves of the two kinds (6) of lime-sulphur mixtures are shown partly in the accompanying graph. It will be seen that the straight line part of the velocity curve of collodial sulphur is much steeper than those of lime-sulphur mixtures.

The writer calculated the relative toxic effect from the graph according to the formula of Powers (7), and obtained the following values:

Colloidal sulphur.............................	0.559
Lime-sulphur I.............................	0.293
Lime-sulphur II.............................	0.103



EXPLANATION OF THE GRAPH.

The graph shows the time-concentration curves for the death of goldfish in colloidal sulphur (C. S. T.). The reciprocal of this curve represents the velocity of fatality (C. S. V.: See Powers, 7); the time to death is arbitrarily divided into 100 in the same sense that that time to go a mile is divided into 60 to give velocity in miles per hour. The velocity of fatality curves of two kinds of colloidal sulphur are also shown for comparison (L. S. I.) (L. S. II.).

From the general character of the curves shown by Powers, the least fatal amount of colloidal sulphur probably lies between 0.001 and 0.008 per cent. Velocity of fatality curves always turn toward lower concentrations in the region of least fatal amounts as indicated by the round dots. The steep slope of the curve indicates greater toxicity than the lime sulphur compounds; the least fatal dose is also greater in the case of the lime sulphur compounds. The lime sulphur compounds were used in the hope that fish might be employed to standarize these insect sprays.

Even at concentrations where the velocity curve of colloidal sulphur is no more a straight line, the toxicity of colloidal sulphur solution seems to be greater than lime-sulphur mixture, which is a compound of sulphur and lime. It will be seen from the table that the survival time varied within a rather wide range. As has already been stated, the samples were not very uniform in nature. The variation in toxicity is considered to be due chiefly to this fact and to the variation in the size of the fish.

ACKNOWLEDGMENTS.

The present study was suggested by Dr. V. E. Shelford and the experiments were conducted under his direction. The writer wishes to thank him heartily for his kindness in allowing the use of his laboratory equipment and for extending many courtesies, including the furnishing of references regarding the occurrence of hydrogen sulphide in water. The writer is also much indebted to Dr. Carver for his kind suggestion and for supply of conductivity water.

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BIOLOGICAL SURVEYS AND INVESTIGATIONS IN MINNESOTA.

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The fact has been long established that certain plants of fish fry and fingerlings, made by both Federal and State departments, end in failure; but the causes underlying the failure are but little understood because of a lack of knowledge of the exact conditions of the waters so planted. The mere fact that a body of water, be it lake or some favorite trout stream, is thought to be all right simply because it was formerly good, but had only become fished out, is the argument most frequently used, and the applicant, be it club or individual, proceeds with this idea and procures fish fry and dumps them in, often at considerable expense to himself, and most certainly to the Government. Then, when no results are forthcoming, blame is attached to the Government (State or Federal) that the fry were either too small, or delivered at the wrong season of the year, and were subsequently washed out by floods, etc., when the real fact of the matter is that the fry would not have been planted if some attention had been given to an investigation of the waters, the nature and amount of its food resources, and extent of the pollution.

The writer, during his boyhood and early manhood, lived near a famous spring, now the site of a Federal hatchery, where brook trout had spawned for untold centuries in great numbers, and probably continue to do so to the present day. Now, this spring and the brook below it for a considerable distance maintained a temperature of 50° to 54°F., winter and summer, which is about the average temperature of all Minnesota springs, and the temperature of the water supplied to most trout hatcheries. As we know the temperature of the water controls the development and subsequent hatching, we infer that the period at which the fry emerge from the shell and their subsequent development near the heads of these spring-fed streams coincides very closely with conditions existing at the hatcheries of the present day. At the big spring under consideration and in the brook below it, my observations showed fry in the creek gravel in the early part of

January, and these must have been swimming up early in February, or about the time of the annual spring freshets of that region, where many of the mountain streams rise to a height of 50 feet above low water, producing torrents, and doing damage the like of which would be impossible anywhere in Minnesota, with the possible exception of some of the North Shore streams. Yet these little fishes withstood the tremendous forces of nature here exerted, and little, if any, diminution of their numbers could be detected until the waters became polluted by the advance of civilization, followed by the devastation of large areas by forest fires, leaving the spring sources deep in the earth to dry up and the waters gradually to subside, often resulting in the complete obliteration of running streams. The causes leading up to this change are an inevitable result of our advance in agriculture and other pursuits connected with our advance in civilization, so that our responsibility to future generations leads us to look more deeply into the causes underlying our failure to do so and so and to search for a remedy. *We can assist nature, but we cannot improve upon her methods.*

It was with a realization of the failures attending certain plants of fish fry in apparently suitable waters that the desire to acquire more or less accurate knowledge of our streams and lakes led to an investigation of certain areas in the state. This was made possible by acts of the legislatures of 1917 and 1919, in appropriating nominal sums for that purpose. The summers of 1918 and 1919 were spent in an investigation along the eastern border of the State in Pine County; the area covered approximately 650 square miles of almost virgin forest country, where all the conditions of pristine wilderness still prevail over large areas. The experience gained in Pine County, and the pressing demand for information from the older-settled regions of the State determined a more fixed policy of procedure, and it was decided each drainage system should be investigated in turn as completely as the circumstances permitted. Therefore, the summer of 1920 was spent in a survey of the Root River basin, a section of the State in which changes first began with its settlement over 80 years ago. This basin covers an area of 1,638 square miles in the southeastern corner of the State, the main stream having a length approximating 151 miles, with many tributaries, one at least being 65 miles long.

We find the development of the agricultural possibilities of this particular region necessitated the removal of a very heavy hard-

wood forest around the headwaters of all the tributaries and the drainage of considerable marsh areas, so that the changes here brought about are particularly noticeable, and will be spoken of more fully in another paragraph. Investigations in the southern quarter of the State show a reduction of the water table of approximately 4 feet during the past 60 to 70 years. While the time devoted to any particular system has been, necessarily, limited, it is believed the results accomplished are worthy of record as adding very materially to a correct understanding of present-day conditions and the problem of meeting these conditions in the future.

As a result of careful study of the conditions affecting the aquatic life of state waters, the following cardinal principles involved in their examination naturally present themselves:

1. Obtain an accurate description of the body of water and locate it definitely on a map drawn to scale.

2. Determine the approximate flow of springs and all sources of supply.

3. Determine the amount and nature of the animal and plant life of the waters and their suitability for maintenance of fish life under existing conditions.

4. Determine the pollution of the waters—its extent, and the probable effect on aquatic life.

5. Study the geographical features of the region, their relation to the permanence of the water supply, any immediate changes now taking place and the probable effect of such changes on a continuance of the existing conditions.

6. Study the effect of flood waters on the plant and animal life; active erosion and its effect.

7. Ascertain, if possible, past conditions of the waters.

8. Report on contemplated drainage of marshes, wet prairie uplands, lakes, etc., in their relation to permanence of the present water supply.

9. Definitely locate the best roads by which the waters are accessible.

The value to the department of working under these principles grows more and more apparent as the work progresses.

The change in conditions affecting our water supply in the southeastern counties has been brought about not so much by actual drainage, as we usually accept it, but more indirectly by deforestation and destruction of the surface-absorbing strata of

soil. Originally this area of the state was clothed with a magnificent hardwood forest, known as the "Big Timber," covering nearly all the plateau-like uplands as well as the valleys, and the rich soil and comparatively level uplands were first cleared and put under cultivation beginning with the early forties, or over 80 years ago.

The actual systematic drainage of marshes and lakes covers an immense territory in the southwestern, western, and northwestern counties, areas, into which we have so far carried on but little investigation. What little we have done proves the conclusiveness of the disastrous results so far as they affect our future water supply and the permanence of our streams.

To what extent drainage, naturally resulting in a greatly reduced evaporation of moisture into the atmosphere during long sustained hot weather, is going to affect the rainfall in years to come is problematical, authorities differing greatly on this point; but it seems to be utter folly to disregard its very probable effect on the precipitation of the future. According to official sources (Water Resources Investigation of Minnesota, St. Paul, 1912) we find the mean annual rainfall of the Mississippi basin in Minnesota to be 27 inches, of which the run-off has varied from 5.1 to 23.9 per cent of the total mean. At St. Paul, where records are continuous since 1837, we find the wettest year (1849) gave 49.7 inches and the driest (1910) but 10.2 inches of precipitation. However, the precipitation appears to be heaviest in the southeastern part of the State, where it is 33 inches, as compared with 24 inches in the western part. The mean precipitation for the Root River basin, the wettest in the State, is 32 inches, where the run-off reaches as high as 27.7 per cent. We find the mean annual for the Red River basin varying from 15 inches on its west border to 26 inches on the east in the lake region; about 75 per cent of this total falls in the six months from April 1 to September 30. The run-off here varies from 5.9 to 23.1 per cent in the timbered region above Fergus Falls, while from the prairie and timbered area below this it varies from 1.8 to 11.3 per cent. From this same report we find the rainfall of the Des Moines basin in southwestern part of the State to be 25 inches.

Even though we admit a normal annual rainfall still persists over much of our territory, in the cultivated regions it now rushes off immediately after every downpour, carrying soil and debris

from the uplands, and gathering momentum as it passes through the deep ravines and gullies, greatly accelerating the action of erosion; and while much of the silt, or soil, of the uplands is carried onwards to the main valley of the Mississippi, vast quantities are deposited on the beds of the smaller streams, so that we find once clean rocky beds are well covered by this sediment.

The removal of the heavy sod formerly covering our prairie lands, the deforestation of the hardwood forest belt, with the attending removal of the centuries-old accumulation of humus and the destruction by fire and pasturage of low-lying shrubbery among the groves of forest left standing creates conditions having tremendous influence on the water supply, in that such lands no longer absorb and hold for gradual release the rainfall on which our springs depend; but, being underlaid with a subsoil or stratum of earth impervious to water, the rainfall rushes off in torrents as soon as it falls. This condition particularly applies to the southeastern counties where, as a result of the deforestation and succeeding intensive cultivation of the uplands, we find many springs so reduced in flow as to have become entirely inadequate to sustain even small running brooks during long continued hot weather, when, of course, evaporation reaches its maximum. This is but one step removed from actual stoppage of flow, and where such conditions exist over an extensive territory, as it does in this instance, it has so reduced the flow in the main streams for miles below, that we can readily become reconciled to the fact that at no long deferred future date such streams will have become intermittent in character, and eventually run only immediately following heavy precipitation. Much of this has been brought about by the necessities of civilization.

The lesson this teaches us is that the permanence of any stream depends primarily on its fountain heads and these in turn are dependent on the adaptability of the soil and its covering of humus to absorb and hold moisture. There can be no sadder experience for the practical conservationist than to wander along a stream bed holding here and there a pool of stagnant water where once a rushing flood full of life meandered its way, and to observe along its course the conditions of wooded banks and slopes conducive to far different results had its headwaters been protected by standing forest or undrained marshes.

STREAMS IN DRAINED AREAS.

As an example of the effect of drainage on lands lying around the headwaters of streams mostly in cultivated areas, usually in the prairie region, we may take the headwaters of Root River in Mower County. Here much of the land is nearly level and the stream itself was originally a succession of prairie sloughs of considerable size connected by running streams over gravel, all being fed by seepage from marshy springs. Considerable areas of these sour, marshy lands have been drained, resulting in such a reduced regular flow into the sloughs as to admit of a highly increased water temperature, and such a reduction in flow that the former running sloughs are mere stagnant pools in midsummer and early fall. The incomplete drainage of these lands has produced results sufficient to clearly indicate that with complete drainage of the area, now under progress, the sloughs will be so reduced very shortly as to function merely as catch-basins during a considerable portion of the year, destroying most of the aquatic life now present, and, as previously pointed out, reducing the flow of the entire stream for miles below. This seems to be the case with hundreds of spring or marsh-fed streams in the prairie region of the southern half of the State, and it is only a question of time till drainage will have absolutely annihilated the aquatic life over a vast area.

However, about 50 per cent of the streams tributary to the eastern half of the Root River are still maintaining themselves by copious springs situated deep in forest-clad, abundantly shaded ravines, and while the food supply usual to such streams is becoming limited, still produce sufficient food to maintain excellent trout fishing throughout their upper waters, but usually warming up to such an extent in the lower half, where they approach the main valley, as to exclude trout from the waters there.

The abandonment of many water power projects, mostly mills, in the Root River and Whitewater basins, is directly traceable to the great reduction in the permanent water supply of those regions.

STREAMS IN FORESTED AREAS SURROUNDED BY INTENSIVELY CULTIVATED LANDS.

The Whitewater valley in Olmsted and Winona counties, to

the traveler following certain sections of its course through the deep wooded canyons, is perhaps one of the most picturesque regions of the State, recalling to mind certain mountain streams of the Pennsylvania Alleghanies, or of New England. The stream bed is rough and rocky with many waterfalls and deep pools, having every appearance of being ideal trout waters. However, as we ascend certain tributaries we find that it is wholly dependent on springs for its supply, and where certain springs have become dry, as we frequently observe, long stretches of the stream cease flowing and exist only as scattered pools of lukewarm water during the late summer months. Here we find no evidence of fish or other aquatic life except in the vicinity of bank springs. The forest growth along the river bottoms and clothing the steep side hills to their summits is very heavy, trees of large size predominating, with abundant undergrowth in many places, indicating but little disturbance of the original forest. On ascending to the crest of the steep slopes and getting clear of the canyon-like valley we find an almost level plateau extending back and away from the course of the stream for miles, all draining, however, at more or less regular intervals through deeply eroded gullies and ravines to the main valley. This plateau, formerly the "Big Timber," is divested of all original forest and almost every square foot of it has been under intensive cultivation for years. Rains often fall on these uplands in perfect deluges and rushing down through the gullies without any restraining influences, carry vast quantities of the soil to the river below where it is responsible for the strangulation of aquatic life referred to under another heading. The results are inevitable, and in spite of all we can do to restock this stream it is gradually, but surely, approaching the day, not far distant, when its only function will be that of an open sewer. The conditions in many parts of the Root River basin are almost identical, and in all probability exist in other basins of that section.

STREAMS IN WILDERNESS COUNTRY AND IN CUT-OVER AREAS.

Much of the North Shore Country remains pretty much as the white man found it 300 years ago, so far as it has affected the water flow of many of the small rivers flowing into Lake Superior and the boundary waters between this and Rainy Lake, though man has taken enormous toll of the heavy forests. This

is due in great measure to the large areas of spruce and tamarack swamps yet undrained, as we note wherever these streams have their sources in dried-up swamps, or when swamps were of but very limited area, as in the country just north of Duluth, there deforestation has very materially reduced the water flow, and the streams, formerly very cold, become very much heated during midsummer.

The removal of the pine forests by the lumbermen has almost invariably been followed by forest fires of great destructiveness, these fires not only sweeping all low-lying shrubs, moss and small trees, but often entering the swamps and either partially or completely killing the timber therein. As an example we can take the great Hinckly fire of 1894. The removal of the white-pine forest had been going on in the Hinckly region for 30 years previously, but serious fires had never gained a footing previous to 1894, when it spread over Pine County clear across to the Wisconsin line. This fire made such a clean sweep that even today, nearly 28 years later, much of the country bears a prairie-like appearance. This fire, however, spared most of the swamps in the eastern part of the county, and the reforestation of the uplands there has been extremely rapid, so that today we find an extremely heavy growth of poplar and other hardwoods wherever the soil will admit of its growth. This country is watered by many small streams fed by numerous small springs, and the borders of all are heavily clothed with brush, or flow through heavy natural meadows, and occasionally through swamps. The swamps lie in such proximity to the spring feeders that at the present time at least conditions have become again much as they are presumed to have been at a time many years preceding the fire, and will probably remain so as long as the swamps which feed the springs are left untouched.

In this region we see an example of what is to eventually transpire unless our whole system of handling such matters is changed. Big Sand Creek, which has its source in a large swamp northeast of Bruno, flows through a country now rapidly being settled up along about one-half of its upper courses. About four years ago it was decided to drain this swamp, and in due course of time this has resulted in the rapid drying-up of the entire headwaters of the creek. Now no fish occur there except an occasional minnow in some of the pools, though at one time it was a most

excellent trout stream. On the other hand the streams of the reforested country south and east of this, previously mentioned as having recuperated since 1894, are now among the best trout streams in the State, for the dense cover along their courses tends to preserve natural conditions of environment, and not only affords shade and food in abundance, but also tends to preserve a low temperature during the heat of summer.

Similar conditions obtain in other parts of the State where cut-over lands have reforested themselves; and in northern Hubbard and southern Beltrami counties the streams have so recuperated that it has been possible to introduce trout with marked success in waters which had previously been uninhabited by any species but pike, pickerel and suckers, the trout being unknown in that region as a natural inhabitant.

In abundance and variety of food supply for fishes many of the streams in cut-over country, where not heavily fired, closely approximate that of wild country, but as soon as the country is divested of this second-growth and put under the plow its change is remarkably rapid, and in an incredibly short time floods and sun do their work and all small animal life disppears. In some of the streams of the southern part of the State it has required but 50 to 75 years to accomplish their ruin, even when the spring-water supply was twice that of other sections, so that it can be realized how rapidly it will be accomplished in a region where the spring-water is limited, and that supply dependent on swamp-seepage for its maintenance.

THE INFLUENCE OF A REDUCED WATER SUPPLY ON AQUATIC ANIMAL LIFE AND ITS BEARING ON POLLUTION.

We can readily understand that with a reduced flow all streams necessarily become more susceptible to pollution. This pollution should be divided into actual sewage waste on the one hand, and long-continued agitation by domestic animals during periods of hot weather, of the accumulated silt bearing minor sewage, on the other, the results, so far as affecting fish-life, being similar.

While sewage pollution is regarded as most highly injurious to fish life, there is considerable question if the silt carried down from the uplands is not even more injurious in the more settled districts, where intensive cultivation of former forested areas

facilitates tremendous erosion at every flood. In most of the streams of southeastern Minnesota the lighter surface soil is carried down and deposited as a thick mass of silt over the bottom, often entirely obliterating all traces of the rocky bed, and covering it like a blanket. This has had the effect of smothering out the clear water Entomostracans, Gammarus, and such aquatic insect larvæ as the caddis-fly during the period of hot weather extending from the last June floods through to October, as during this period cattle, hogs and sheep, great herds of which are pastured along the banks with free access to the stream, keep the water in constant agitation by standing most of the day in it; and during a season of the year when such streams were naturally most clear, they produce a condition of intense roiliness, in which some small aquatic life can not exist, and in which fishes will not remain, if we except undesirable species as the carp for instance.

If a stream is thus divested of the natural food supply for the smaller fishes, it seems hardly advisable to attempt to reintroduce even adult fishes in its waters, as it is only a question of time until they will either be caught or desert the stream in search of food and clear water; and since no food exists for their progeny, even though they spawn in great numbers, it would be the height of folly to attempt to introduce fry into such streams. Many streams in southern Minnesota are found to have reached this condition, and while from casual observation, they have the appearance of being suitable for trout, on more careful examination they are found to be absolutely devoid of small animal life.

BARNYARD POLLUTION.

Ordinarily it has been found that barnyard pollution has but little effect on most streams, the most pronounced effect being noted in the case of springs with a comparatively weak flow (50 gallons or less) situated in a barnyard which drains directly into it. In the case of large springs this pollution seems to have little bearing on the aquatic life, an example of this kind being the large spring about a mile east of Spring Valley, coming out from underneath a barn and continuously frequented by ducks, geese, hogs and cattle; a few trout exist here apparently in the best of condition, but in this case the heavy growth of water cress apparently purifies and balances the water. On the other

hand, when the water supply becomes reduced to a weak sluggish flow like the upper waters of Mill Creek at Chatfield, the many barnyards situated along its course have a telling effect and create conditions which aquatic life can not withstand.

Other matters besides pollution have a tremendous influence on the conservation of our fish life. One of them is the carelessness or indifference of owners of power projects along some of our important streams. In one instance complaint had been made of certain devastation of spawning beds in one of our rivers which demanded investigation. Quite by accident it was found that a far more serious offense was being committed weekly by the owner of a large mill who every Saturday evening at 6 o'clock shut down his turbines and conserved every ounce of water until Monday at 7 a. m., in order to raise a head. In doing this he exposed the active river bed for several miles below, and bass and crappie nests were found high and dry, resulting in the utter destruction of thousands of fish; yet no one complained of this, though they were up in arms over a matter doing less than a hundredth part of the destruction caused by this mill owner in cutting off the overflow at his dam.

RESULTS AS APPLIED TO STOCKING OF STREAMS.

As previously stated it appears that many waters have become unfitted for certain fishes, but admit of the substitution of an almost equally desirable species. For instance, certain brook trout waters have become much warmer than formerly without an appreciable diminution of the food supply; in such waters the introduction of the brown trout has met with signal success. Another means of great saving in these changed waters has been the determination of the available food supply for young fishes, whereby a far more conservative estimate of the number such a stream would actually support has been made and fry planted in accordance therewith. Previous to a critical examination thousands of fry had been dumped into certain streams where but little food existed, resulting in overstocking, and naturally ending in almost complete failure. We, therefore, see the application of the results of these surveys has been the elimination of waste in the distribution of fry and the substitution of suitable for unsuitable species. These two remedies, elimina-

tion and substitution, have, therefore, been a means of more saving to the department than the entire cost of the surveys.

LAKE SURVEYS.

Investigations for the improvement of lakes have not merely required biological investigations, but have presented civil engineering problems as well, and have required a more extensive survey than observations for streams. The most extensive work of this character has been done in the southern part of the State, where the results show most clearly the subsidence of the water-table. Lake Shetek in Murray County is one of the largest lakes so surveyed, having a shore-line of over 15½ miles. For many years the level of this lake was controlled by a dam across the stream below its outlet, the dam having been rebuilt several times, each time a little higher, so that when it was finally abandoned for water power with the disappearance of the dam a few years ago, the abnormal water level so long sustained had entirely destroyed the original contour of the lake and made its restoration to its original meander level a problem of no mean importance. Flood waters at its maximum artificial level had inundated the high banks and washed them into the lake back a distance of a hundred feet in some instances, the dirt so washed in aiding enormously in filling up the natural shallow bed of the lake until it is now found not to exceed 8 feet in depth anywhere at extreme low water such as prevailed during the past summer (1921). The destruction of so great an area of original shore-line, and all landmarks along with it, rendered a determination of its original level, fixed in 1861 by Government survey, difficult in the extreme, and the position of original meander corners could only be definitely determined by a resurvey of lines from section corners beginning at considerable distances from the lake shore.

The accurate determination of the original meander is vital, as we can not exceed its level without considerable damage to surrounding lands, thereby laying the foundation for numerous suits for damages from the owners. The actual filling up of this lake bed, however, has not so seriously affected it as the destruction of its aquatic plant life which has been almost absolute; it has been claimed that the disappearance of this plant life is due to the carp, and probably some of it has been destroyed by

that fish, but by far the greater bulk of it has been smothered by sand and clay. The lake at its normal level is connected with large slough-like ponds at this time filled with aquatic plants, and as these ponds have always been connected with it, it would seem very improbable that the carp would discriminate in their favor if it alone were responsible for the destruction of the vegetation. As these ponds, with their heavy growth of vegetation, are literally alive with the best natural food for young fishes, and the lake itself almost barren of like food, the most important problem connected with its restoration is the construction of a dam at its natural outlet sufficiently high to give the fish access to the ponds.

A problem of an entirely different character is presented in the case of Cannon Lake, in Rice County, through which Cannon River passes. Here we find if we construct a dam to raise the lake to a level for proper winter storage, we cut off all access to the natural spawning grounds of the fish in a small lake below. Both this small lake and the main lake are level-controlled by a power dam in operation for many years at a short distance below the smaller lake. Under normal weather conditions this power dam maintains a fair level in the two lakes, but under the subnormal weather of the past summer the dam was inadequate to control the levels, even though water was consumed for a very short period weekly, and in spite of the efforts of the owners of the power dam to conserve water, it subsided far below normal. This seems to be the inevitable result of too much drainage on the headwaters of the river itself, but fortunately occurs only during seasons of long-sustained drought.

SUMMARY.

The lessons derived from these investigations show us:

1. That certain streams, happily in the minority, are unsuitable for restocking, and have been dropped from the list.
2. The substitution of brown trout in stocking certain waters produces excellent results where repeated failures have been made with brook trout.
3. An absence of proper food for young fish, mostly semi-microscopic food, accounts for repeated failures in restocking depleted streams and lakes.
4. That much of the so-called destruction of aquatic plants by the carp is not borne out by the facts.

5. Spring-fed streams in burnt-over, reforested areas are among the best trout streams in the State.
6. Deforestation, with accompanying cultivation around the headwaters of spring-fed streams, is very rapidly diminishing the water supply.
7. The water-table in the southern part of the State has been lowered 3 to 4 feet.
8. Barnyard pollution has little effect on fish life unless the water flow is so reduced as to make the waters of very questionable value even if not polluted.
9. Sewage waste and muddy water during long-sustained hot weather have very decided injurious effects, the former by direct action, the latter through the destruction of the smaller aquatic life, both animal and plant.

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'09 VAN ATTA, CLYDE H., U. S. Bureau of Fisheries, Leadville, Colo.
'19 VAN CLEAVE, PROF. H. J., University of Illinois, Urbana, Ill.
'14 *VANDERGRIFT, S. H., 1728 New Hampshire Ave., Washington, D. C.

'20 VICKERS, HARRISON W., Chairman, Conservation Commission, 512 Munsey Building, Baltimore, Md.
'19 VINCENT, W. S., U. S. Bureau of Fisheries, Mammoth Springs, Ark.
'19 VIOSCA, PERCY, JR., Natural History Bldg., New Orleans, La.
'12 VOGT, JAMES H., Nevada Fish Commission, Verdi, Nevada.
'09 VON LENGERKE, J., 200 Fifth Ave., New York City.
'06 WADDELL, JOHN, Grand Rapids, Mich.
'19 WAGNER, JOHN, School House Lane, Germantown, Philadelphia, Pa.
'15 WAKEFIELD, L. H., 1310 Smith Bldg., Seattle, Wash.
'22 WALCOTT, FREDERIC C., Pres., Board of Fisheries and Game, Norfolk, Conn.
'96 WALKER, BRYANT, Detroit, Mich.
'11 WALKER, DR. H. T., 210 Main St., Denison, Texas.
'20 WALKER, S. J., District Inspector of Hatcheries, Ottawa, Canada.
'16 WALLACE, FREDERICK WILLIAM, 282 W. 25th St., New York, N. Y.
'96 WALTERS, C. H., Cold Spring Harbor, N. Y.
'98 WARD, DR. H. B., University of Illinois, Urbana, Ill.
'12 WARD, J. QUINCY, Executive Agent, Kentucky Game and Fish Commission, Frankfort, Ky.
'17 WARD, ROBERTSON S., 172 Harrison St., East Orange, N. J.
'13 WEBB, W. SEWARD, 44th St. and Vanderbilt Ave., New York City.
'21 WEBSTER, B. O., Commissioner of Fisheries, Madison, Wis.
'16 WEEKS, ANDREW GRAY, 8 Congress St., Boston, Mass.
'22 WELLS, ARTHUR W., U. S. Bureau of Fisheries, Washington, D. C.
'20 WELLS, WM. F., Conservation Commission, Albany, N. Y.
'19 WHEELER, CHAS. E., Stratford, Conn.
'15 WHEELER, FRED M., 546 Fulton St., Chicago, Ill.
'21 WHITE, DR. E. HAMILTON, 298 Stanley St., Montreal, Canada.
'10 WHITMAN, EDWARD C., Canso, Nova Scotia, Canada.
'15 WHITESIDE, R. B., 204 Sellwood Bldg., Duluth, Minn.
'20 WHITEWAY, SOLOMAN, P., St. Johns, Newfoundland.
'19 WICKLIFF, EDWARD L., 1309 Atchison St., Columbus, Ohio.
'20 WILBUR, HARRY C., Commissioner, Sea and Shore Fisheries, Portland, Me.
'01 WILSON, C. H., Glen Falls, N. Y.
'00 WINN, DENNIS, U. S. Bureau of Fisheries, 1217 L. C. Smith Bldg., Seattle, Wash.
'99 WIRES, S. P., U. S. Bureau of Fisheries, Duluth, Minn.
'13 *WISNER, J. NELSON, Director, Institute de Pesca del Uruguay, Punta del Esto, Uruguay.
'21 WOLF, CHARLES F., Birchwood, Wis.
'05 *WOLTERS, CHAS. A., Oxford and Marvine Sts., Philadelphia, Pa.
'97 WOOD, C. C., Plymouth, Mass.
'13 WOODS, JOHN P., President, Missouri State Fish Commission, First and Wright Sts., St. Louis, Mo.
'14 WORK, GERALD, Perkins Hill, Akron, Ohio.
'19 WRIGHT, PROF. ALBERT HAZEN, Cornell University, Ithaca, N. Y.
'16 YOUNGER, R. J., Houma, La.
'99 ZALSMAN, P. G., Supt., State Fish Hatchery, Grayling, Mich.

Recapitulation

Honorary	63
Corresponding	12
Patrons	53
Active (including 49 clubs, 19 libraries and 9 State organizations)	569
Total	697

CONSTITUTION

(As amended to date)

ARTICLE I

NAME AND OBJECT

The name of this Society shall be American Fisheries Society. Its object shall be to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; the uniting and encouraging of all interests of fish culture and the fisheries, and the treatment of all questions regarding fish, of a scientific and economic character.

ARTICLE II

MEMBERSHIP

Active Members.—Any person may upon a two-thirds vote and the payment of three dollars, become a member of this Society. In case members do not pay their fees, which shall be three dollars per year after first year, and are delinquent for two years, they shall be notified by the treasurer, and if the amount due is not paid within a month thereafter, they shall be, without further notice, dropped from the roll of membership.

Any sporting or fishing club, society, firm, or corporation, upon two-thirds vote and the payment of an annual fee of five dollars, may become a member of this Society and be entitled to all its publications. Libraries shall be admitted to membership at three dollars a year.

Any state board or commission may, upon the payment of an annual fee of ten dollars, become a member of this Society and be entitled to all of its publications.

Life Members.—Any person shall, upon a two-thirds vote and the payment of twenty-five dollars, become a life member of this Society, and shall thereafter be exempt from all annual dues.

Patrons.—Any person, society, club, firm, or corporation, on approval by the Executive Committee and on payment of $50.00,

may become a Patron of this Society with all the privileges of a life member, and then shall be listed as such in all published lists of the Society. The money thus received shall become part of the permanent funds of the Society and the interest alone be used as the Society shall designate.

Honorary and Corresponding Members.—Any person can be made an honorary or a corresponding member upon a two-thirds vote of the members present at any regular meeting.

The President (by name) of the United States and the Governors (by name) of the several States shall be honorary members of the Society.

Election of Members Between Annual Meetings.—The President, Recording Secretary, and Treasurer of the Society are hereby authorized, during the time intervening between annual meetings, to act on all individual applications for membership in the Society, a majority vote of the Committee to elect or reject such applications as may be duly made.

ARTICLE III

SECTIONS

On presentation of a formal written petition signed by one hundred or more members, the Executive Committee of the American Fisheries Society may approve the formation in any region of a Section of the American Fisheries Society to be known as the ——— Section.

Such a Section may organize by electing its own officers, and by adopting such rules as are not in conflict with the Constitution and By-Laws of the American Fisheries Society.

It may hold meetings and otherwise advance the general interests of the Society, except that the time and place of its annual meeting must receive the approval of the Executive Committee of the American Fisheries Society, and that without specific vote of the American Fisheries Society, the Section shall not commit itself to any expression of public policy on fishing matters.

It may further incur indebtedness to an amount necessary for the conduct of its work not to exceed one-half of the sum received in annual dues from members of said Section.

Such bills duly approved by the Chairman and Recorder of the Section shall be paid on presentation to the Treasurer of the American Fisheries Society.

ARTICLE IV

OFFICERS

The officers of this Society shall be a president and a vice-president, who shall be ineligible for election to the same office until a year after the expiration of their term; an executive secretary, a recording secretary, a treasurer, and an executive committee of seven, which, with the officers before named, shall form a council and transact such business as may be necessary when the Society is not in session—four to constitute a quorum.

In addition to the officers above named there shall be elected annually five vice-presidents who shall be in charge of the following five divisions or sections:

1. Fish culture.
2. Commercial fishing.
3. Aquatic biology and physics.
4. Angling.
5. Protection and legislation.

Vice-presidents of sections may be called upon by the President to present reports of the work of their sections, or they may voluntarily present such reports when material of particular value can be offered by a given division.

ARTICLE V

MEETINGS

The regular meeting of the Society shall be held once a year, the time and place being decided upon at the previous meeting, or, in default of such action, by the executive committe.

ARTICLE VI

ORDER OF BUSINESS

1. Call to order by president.
2. Roll call of members.
3. Applications for membership.
4. Reports of officers.
   a. President.
   b. Secretary.
   c. Treasurer.
   d. Vice-presidents of Divisions.
   e. Standing Committees.

5. Committees appointed by the president.
   a. Committee of five on nomination of officers for ensuing year.
   b. Committee of three on time and place of next meeting.
   c. Auditing committee of three.
   d. Committee of three on program.
   e. Committee of three on publication.
   f. Committee of three on publicity.
6. Reading of papers and discussion of same.
   (Note—in the reading of papers preference shall be given to the members present.)
7. Miscellaneous business.
8. Adjournment.

ARTICLE VII

CHANGING THE CONSTITUTION

The Constitution of the Society may be amended, altered or repealed by a two-thirds vote of the members present at any regular meeting, provided at least fifteen members are present at said regular meeting.